U.S. Environmental Protection Agency
Office of Resource Conservation and Recovery

Electronics Waste Management in the United States Through 2009

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Prepared by ICF International

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Office of Resource Conservation and Recovery

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1. Introduction

Background

Consumer electronics have become increasingly popular and culturally important over the past several decades, changing how we communicate, entertain ourselves, and get information — and the speed with which we do so. As the nature, use, and number of electronic products change over time, patterns of sales, storage, and end-of-life management also change. Waste managers, manufacturers, and policymakers need reliable and current information to inform and improve the management of used electronics. This report updates EPA's 2008 report, *Electronics Waste Management in the United States: Approach 1*.

We estimate that in 2009:

- 438 million new electronic products were sold;
- 5 million short tons of electronic products were in storage;
- 2.37 million short tons of electronic products were ready for end-of-life management; and
- 25 percent of these tons were collected for recycling.

Electronics comprise approximately one to two percent of the municipal solid waste stream but they garner a great deal of interest for several reasons:

1. Rapid growth and change in this product sector, leading to a constant stream of new product offerings and a wide array of used products needing appropriate management;
2. The intensive energy and diverse material inputs that go into manufacturing electronic products, represent a high degree of embodied energy and scarce resources, many of which can be recovered;
3. The presence of substances of concern in some electronics, particularly older products, which merit greater consideration for safe end-of-life management; and
4. The opportunities for resource conservation and recovery through improved collection and recycling of electronics.

Through a variety of initiatives, EPA has been helping to improve the design and safe recycling of electronic products. While electronics can be safely disposed in properly managed landfills, there are significant environmental and economic benefits to recycling: preserving scarce materials, minimizing impacts of extractive industries, facilitating recovery of materials, and reducing the energy and resources used in manufacturing new electronic products.

Product Scope

This report addresses consumer electronic products, from both residential and commercial/institutional users, that were manufactured or imported for sale in the United States from 1980 through 2010. The study encompasses the following product categories:

- Personal computers (PCs): desktop central processing units (CPUs) and portables
- Computer displays: cathode ray tube (CRT) monitors and flat-panel monitors
- Keyboards and mice
- Hard-copy devices: printers, fax machines, scanners, digital copiers, and multi-function devices
- Televisions (TVs): monochrome, cathode ray tube (CRT), flat-panel, and projection
- Mobile devices: cell phones, personal digital assistants (PDAs), smartphones, and pagers

Further description of the product categories is provided in Appendix A. Categories were chosen to cover a broad range of electronic products that are targeted by recycling initiatives at the federal, state, and local levels.

2. Methodology

Overview and Approach

Figure 1 provides a life cycle flow chart for electronic products and also identifies the stages included in the scope of this report. The life cycle of electronic products includes: raw materials acquisition and manufacturing, purchase and use, storage, and end-of-life management (i.e. disposal or collection for recycling). This report models the number and weight of electronic products that are in use, storage, and end-of-life management in a given year; extending from purchase to the point when the product is either disposed or collected for recycling. The subsequent management and processing of electronic products that were collected for recycling involves a different methodology which the Agency has not yet developed. Consequently, this report does not address or attempt to quantify the portion of electronic products collected for recycling that are subsequently exported.

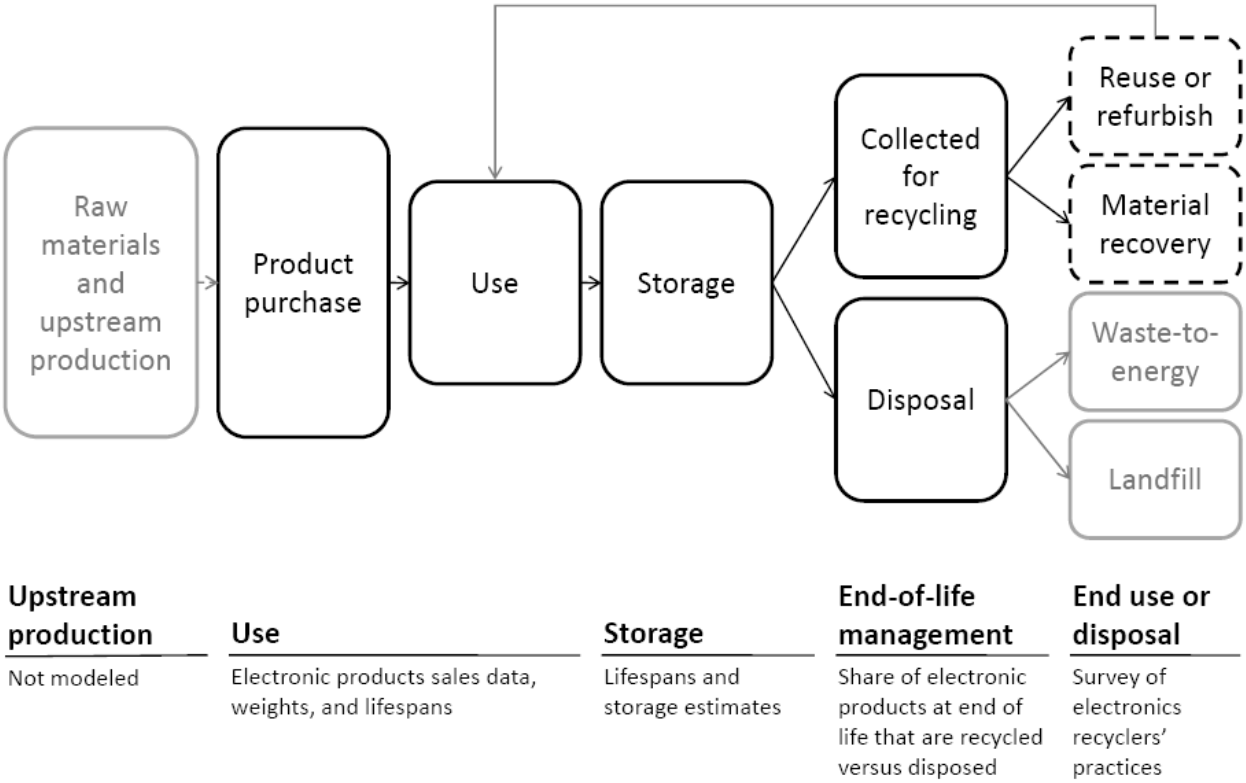

Figure 1: Life-cycle flow chart for electronic products. *Solid boxes refer to life cycle stages that were modeled in this report; dashed boxes refer to stages where information was collected by recycler surveys. Gray boxes refer to stages that were not included*

Figure 1 also describes the data collected at each life cycle stage included in this study. We used sales data to determine the number of electronic products entering use for a given year and weight data to estimate the weight of these products. We applied data on the lifespan of electronic products to the sales data to estimate the number and weight of products in use, storage, or end-of-life management for each year. Finally, we used data on the share of electronic products that are collected for recycling or disposed of to estimate how products are managed at their end-of-life.

An earlier EPA study of electronics life cycles distinguished between two or more phases in the "use" stage of the life cycle, generally "first use" and "second use." (EPA 2007) "First use" indicates use by the original purchaser of the product. When the first user no longer uses the electronic product they may sell or give the product to another person, which is termed "second use." The current analysis makes

no distinction between first users and subsequent users in the "use" stage. Since the ultimate goal of this study is to model when electronic products are ready for end-of-life management, the pattern of use before this stage makes no practical difference to the outcome.

We consider storage a separate stage, however, since the functional amount of time that an electronic product is in use does not necessarily correlate with how long users store it when they have stopped using it. Therefore, since assumptions about storage behavior affect when an electronics product is ready for end-of-life management, we have found it useful to think about "use" and "storage" separately, using the sum of both to define the total lifespan of a product.

When the owner of an electronic product decides to send it to a third party for handling and management, the product enters the end-of-life management stage. Either the electronic product will be disposed or it will be collected for recycling. Products collected for recycling may be reused, refurbished, or dismantled or shredded for material recovery within the United States, or in other countries. This report does not track or quantify exports of electronics collected for recycling. Products that are not collected for recycling are disposed of, primarily in landfills. Combustible components, such as plastics, may be collected and sent to waste-to-energy incinerators, which is also not addressed in this report.

Data and Assumptions

This section presents the data sources and assumptions used to estimate the amounts of used and end-of-life electronics. The data includes:

- Sales data for each product type by model year;
- Weight data for each product type by model year;
- Lifespans— the length of time products are used and kept in storage before being collected for recycling or disposed—for each product type, and;
- The quantities of electronic products that are disposed or collected for recycling each year.

- Product Sales Data –

To estimate sales, we compiled the number of products shipped by model year for each type of product. Shipment data represents manufacturer shipments of electronic products, not the actual sales of products at retailers; we assume that shipment data is equivalent to sales data.

We used International Data Corporation (IDC) shipment data (EPA 2008; Vokes 2009) for computers, hard-copy devices, keyboards and mice, and CRT and flat-panel PC monitors up to 2007. We projected sales for 2008-2010 based on trends in the IDC (2006b) data and personal communications with expert, Kathleen Vokes (2009).

The Consumer Electronics Association (CEA) provided shipment data for CRT, flat-panel, projection, and monochrome TVs through 2009 (EPA 2008; CEA 2009). We projected sales for 2010 based on the 2008 and 2009 sales trend.

Cell phone shipment estimates were taken from estimates by Fishbein (2002), IDC, and CEA; these data were extrapolated to 2008 through 2010 assuming a nine percent annual growth rate based on sales of mobile devices between 2004 and 2009 (CEA 2009). Mobile device sales data were the most difficult to locate, given the large number of different product types, the rapid growth in sales over recent years, and the wide use of these devices by both residential and commercial users. There is more uncertainty in our projection of mobile device sales than for the other product categories, which are based on actual sales estimates from providers that compile internally-consistent datasets.

Refer to Appendix C for a complete summary of the data sources used to estimate electronic products sales.

Figure 2 presents the number of electronic products sold in the United States by model year. Using the sales data from the sources detailed in Appendix C, we estimate that 438 million electronic products were sold in 2009, with a projected 440 million in electronic products sales in 2010, as shown in Table 1 below.

This represents a doubling of product sales from 1997, driven by a nine-fold increase in mobile device sales. The increase in mobile device sales has offset a slight decline in the total sales across other categories, which are projected to drop from 215 million electronic products in 1998 to 208 million electronic products in 2010. As a result, mobile device sales are projected to account for 53 percent of sales across all product categories in 2010, compared to 12 percent of sales in 1998.

- Product Weight Data –

Modeling the weight of products is useful from an end-of-life management perspective because it provides information on the flow of material through the life cycle of electronic products sold in the United States. To convert the number of electronic products sold into tonnages sold for each model year, we collected data on the typical weight of individual electronic products by model year, as shown in Table 2.

Data from the Florida Department of Environmental Protection (DEP) were used to develop weight estimates for desktop CPUs, hard-copy devices, PC flat panels, and CRT TVs prior to 2008. For the remaining categories, estimates were taken from *Consumer Reports* Annual and Monthly Buying Guides (from 1984 to 1999) and online information.

We updated unit weight data for desktop CPUs, portables, multi-function devices, mobile devices, and flat-panel TVs in the 2008, 2009, and 2010 model-years using 2008 and 2009 *Consumer Reports* Buying Guides and online manufacturer specification sheets.[1] For each type of product, we sampled weights across a range of model sizes to calculate a typical weight. We were unable to calculate a sales share-weighted average weight for each product, however, because the data on the sales share of individual models within each type of product were not available.

Figure 3 presents the sales data for electronic products by model year in terms of product weight. Even with an estimated 33-percent increase in unit sales compared to 2000, as mobile devices sales have sharply increased and electronic products have become lighter, the total weight of products sold in 2010 is estimated to decrease by nearly 15 percent relative to 2000. The drop in weight is largely driven by rapid declines in sales of CRT TVs, CRT monitors, and desktop CPUs.

[1] In the updated weight data the average weight of flat-panel TVs was nearly three times larger than assumed in the 2008 report. We revised the historical trend by extrapolating the trend in average weight for popular flat panel models in 2005 and 2009 over the period from 1998 (the first year flat-panel TVs were sold) through 2010.

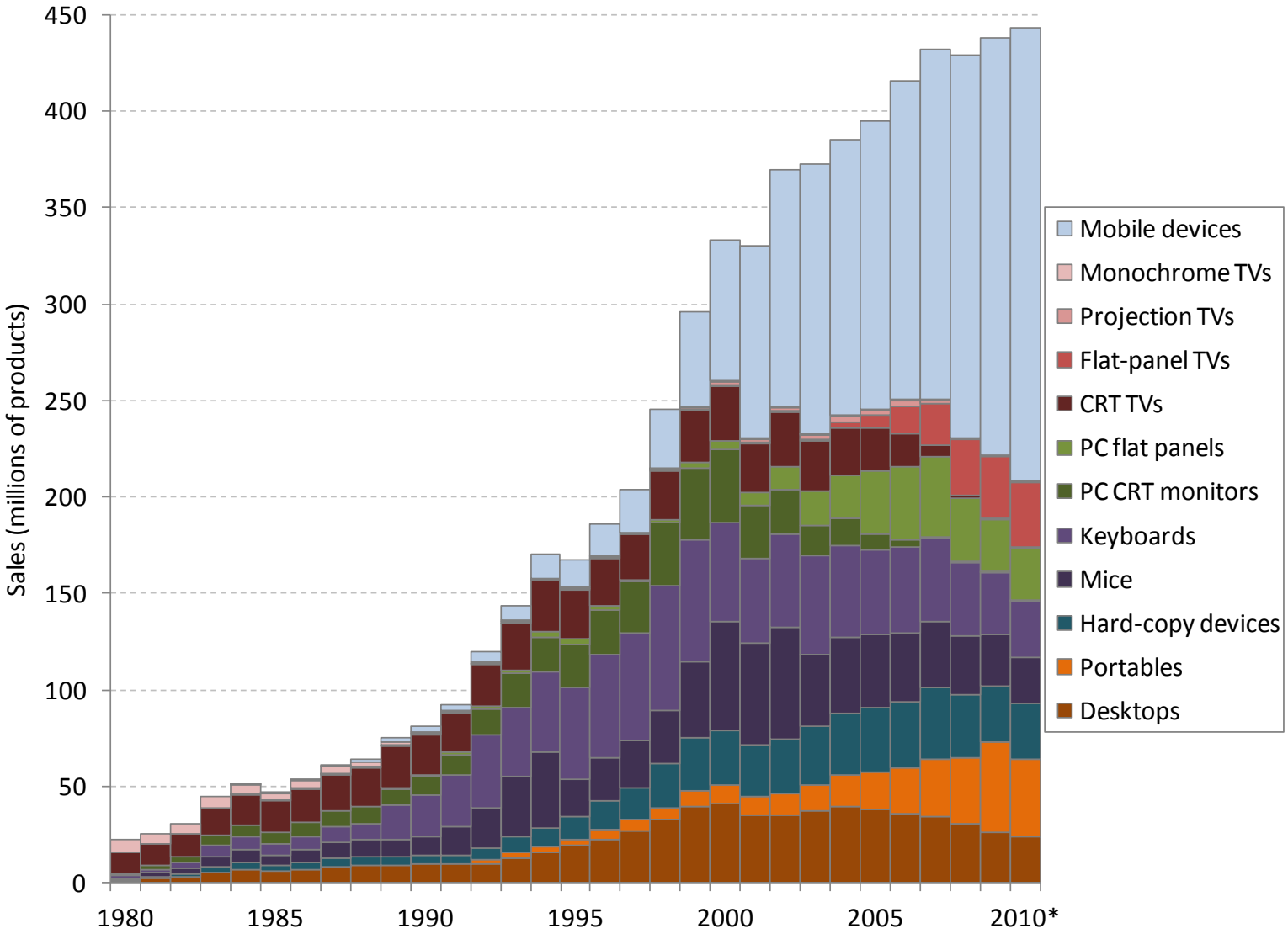

Figure 2: Sales of electronic products by model year, in number of units sold. **Results for 2010 are projected based on estimates from previous years.*

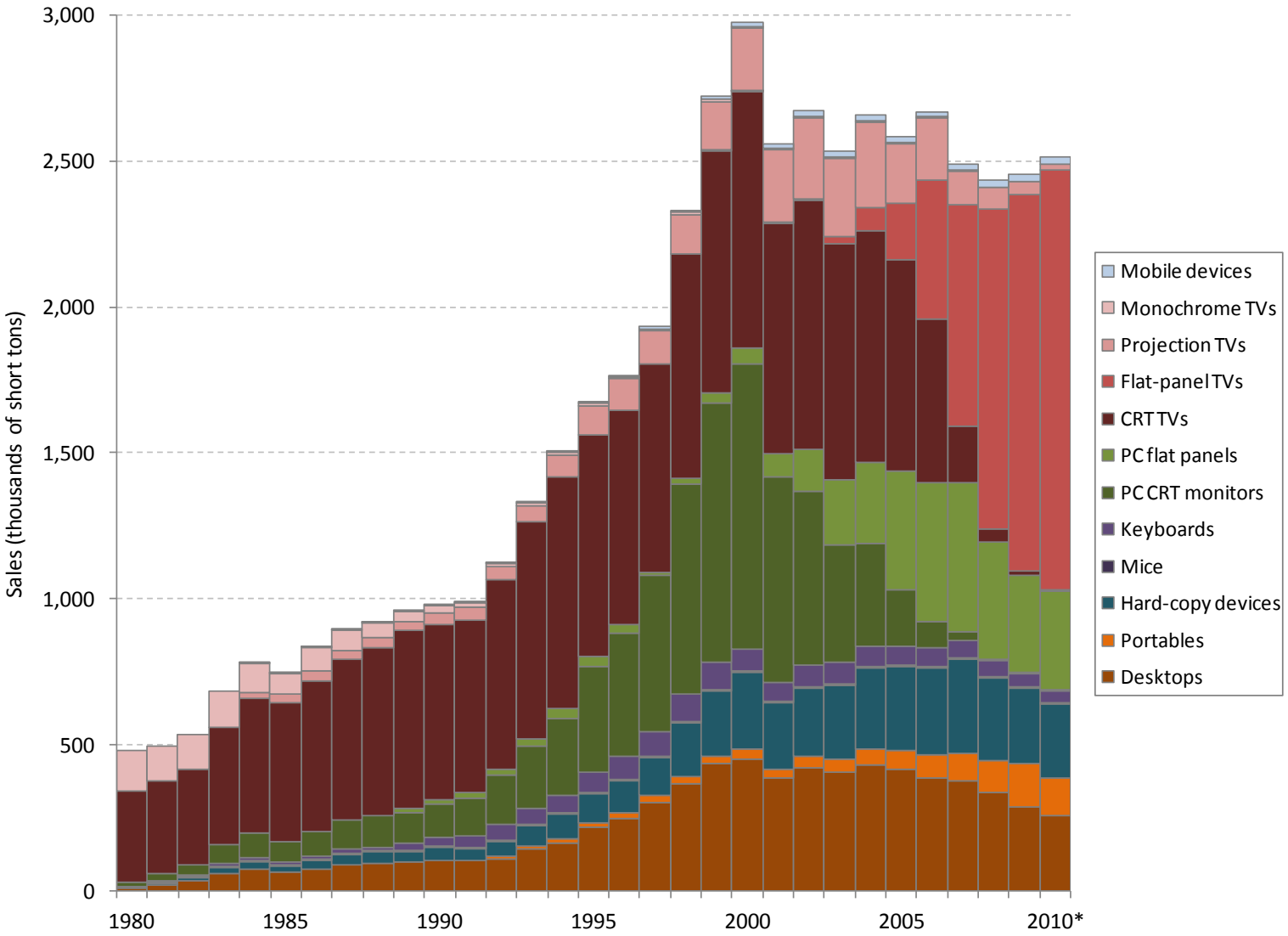

Figure 3: Sales of electronic products by model year, short tons of products sold. **Results for 2010 are projected based on estimates from previous years.*

Table 1: Sales of electronic products, by product category and model year (in number of units). **Projected sales based on sales from previous years and available data sources. See Appendix C for full listing of data sources.*

Model year	Computers		Computer Peripherals			Computer Displays		Televisions					Mobile devices
	Desktop CPUs	Portables	Hard-copy devices	Mice	Keyboards	PC CRT monitors	PC flat panels	CRT TVs < 19"	CRT TVs >= 19"	Flat-panel TVs	Projection TVs	Monochrome TVs	Mobile devices
1980	980,600	0	514,800	980,600	980,600	980,600	0	5,449,000	5,449,000	0	0	6,684,000	0
1981	1,961,000	0	1,030,000	1,961,000	1,961,000	1,961,000	0	5,579,000	5,579,000	0	0	5,654,000	0
1982	3,040,000	0	1,596,000	3,040,000	3,040,000	3,040,000	0	5,683,000	5,683,000	0	0	5,692,000	0
1983	5,450,000	0	2,861,000	5,450,000	5,450,000	5,450,000	0	6,993,000	6,993,000	0	0	5,735,000	0
1984	6,660,000	0	3,497,000	6,660,000	6,660,000	6,660,000	0	8,042,000	8,042,000	0	195,000	5,050,000	35,210
1985	5,760,000	0	3,024,000	5,760,000	5,760,000	5,760,000	0	8,415,000	8,415,000	0	266,000	3,684,000	105,600
1986	6,851,000	0	3,597,000	6,851,000	6,851,000	6,851,000	0	9,102,000	9,102,000	0	304,000	3,953,000	401,400
1987	8,202,000	0	4,306,000	8,202,000	8,202,000	8,202,000	0	9,665,000	9,665,000	0	293,000	3,547,000	795,800
1988	8,724,000	0	4,580,000	8,724,000	8,724,000	8,724,000	0	10,110,000	10,110,000	0	302,000	2,574,000	1,254,000
1989	8,906,000	0	4,676,000	8,906,000	17,520,000	8,389,000	1,084,000	10,850,000	10,850,000	0	265,000	1,656,000	2,113,000
1990	9,486,000	0	4,980,000	9,486,000	21,740,000	9,398,000	882,700	10,400,000	10,400,000	0	351,000	1,411,000	2,577,000
1991	9,524,000	0	5,000,000	14,290,000	26,960,000	10,480,000	1,500,000	9,418,000	10,720,000	0	380,000	784,000	3,366,000
1992	9,911,000	1,850,000	6,175,000	20,860,000	37,630,000	13,400,000	1,727,000	9,734,000	12,260,000	0	404,000	633,000	5,387,000
1993	13,020,000	2,528,000	8,164,000	31,270,000	36,060,000	17,340,000	1,840,000	10,620,000	14,010,000	0	465,000	550,000	7,873,000
1994	15,300,000	3,200,000	9,711,000	39,740,000	41,440,000	18,070,000	2,795,000	11,680,000	15,050,000	0	636,000	540,000	12,430,000
1995	19,140,000	3,564,000	11,920,000	19,140,000	47,600,000	22,230,000	2,967,000	10,850,000	14,590,000	0	820,000	480,000	14,500,000
1996	22,420,000	4,949,000	14,930,000	22,420,000	53,750,000	23,060,000	2,266,000	10,110,000	14,470,000	0	887,000	425,000	16,600,000
1997	26,770,000	6,000,000	16,240,000	24,870,000	55,600,000	26,580,000	947,100	9,572,000	14,030,000	0	917,000	400,000	22,200,000
1998	32,530,000	6,408,000	22,500,000	27,890,000	64,960,000	32,580,000	1,468,000	10,300,000	15,050,000	0	1,082,000	347,000	30,600,000
1999	39,490,000	7,871,000	27,500,000	39,490,000	63,680,000	36,940,000	2,830,000	11,220,000	16,430,000	1,631	1,332,000	320,000	49,300,000
2000	40,820,000	9,623,000	28,670,000	56,160,000	51,730,000	37,470,000	4,770,000	12,230,000	17,060,000	7,552	1,703,000	265,000	72,900,000
2001	35,090,000	9,575,000	26,750,000	53,000,000	43,810,000	27,240,000	6,598,000	9,773,000	16,380,000	54,080	1,970,000	250,000	100,100,000
2002	35,080,000	10,880,000	28,740,000	57,540,000	48,590,000	23,300,000	11,650,000	11,680,000	17,010,000	191,300	2,486,000	225,000	122,300,000
2003	36,960,000	13,810,000	30,660,000	36,960,000	51,260,000	15,760,000	18,050,000	8,304,000	17,560,000	955,200	2,720,000	200,000	140,000,000
2004	39,350,000	16,620,000	32,200,000	39,350,000	47,220,000	13,950,000	22,670,000	6,938,000	17,840,000	2,712,000	3,510,000	150,000	142,700,000
2005	38,050,000	19,620,000	33,140,000	38,050,000	44,150,000	7,757,000	33,000,000	5,441,000	16,730,000	6,366,000	2,965,000	125,000	150,000,000
2006	35,420,000	24,300,000	34,320,000	35,420,000	44,580,000	3,484,000	38,560,000*	3,427,000	13,450,000	14,490,000	3,064,000	110,000	165,100,000
2007	34,210,000	30,020,000	36,910,000	34,210,000	43,100,000	1,018,000	41,580,000*	2,093,000	4,205,000	21,450,000	1,671,000	50,000	181,900,000
2008	30,500,000	34,110,000	33,090,000*	30,500,000	38,400,000	142,400*	32,670,000*	447,000	877,000	29,060,000	1,070,000	0	198,300,000*
2009	26,310,000	46,440,000	29,510,000*	26,310,000	33,100,000	19,510*	27,190,000*	128,900	347,100	32,100,000	628,000	0	216,100,000*
2010	23,500,784*	40,420,000	29430,000*	23,500,000	29,600,000	19,700*	27,450,000*	37,170*	137,400*	33,690,000*	251,200*	0	235,600,000*

Table 2: Weights of electronic products, by product category and model year (in pounds). **Weights for 2010 based on estimates from previous years.*

Model year	Computers		Computer Peripherals			Computer Displays		Televisions					Mobile devices
	Desktop CPUs	Portables	Hard-copy devices	Mice	Keyboards	PC CRT monitors	PC flat panels	CRT TVs < 19"	CRT TVs >= 19"	Flat-panel TVs	Projection TVs	Monochrome TVs	Mobile devices
1980	22.0		18.0	0.2	2.9	24.5		42.0	73.0			42.0	
1981	22.0		18.0	0.2	2.9	24.5		42.0	73.0			42.0	
1982	22.0		18.0	0.2	2.9	24.5		42.0	73.0			42.0	
1983	22.0		18.0	0.2	2.9	24.5		42.0	73.0			42.0	3.5
1984	22.0		18.0	0.2	2.9	24.5		42.0	73.0		219.0	42.0	3.5
1985	22.0		18.0	0.2	2.9	24.5		40.6	72.6		221.0	40.6	3.5
1986	22.0		18.0	0.2	2.9	24.5		41.1	73.0		223.0	41.1	3.5
1987	22.0		18.0	0.2	2.9	24.5		40.8	73.0		225.0	40.8	3.5
1988	22.0		18.0	0.2	2.9	24.5		41.2	72.9		227.0	41.2	3.5
1989	21.9		17.9	0.2	2.9	24.5	24.6	41.0	71.7	29.0	229.0	41.0	3.5
1990	21.8		19.6	0.2	2.9	24.6	24.6	40.5	74.8	29.0	231.0	40.5	3.5
1991	21.8		18.4	0.2	2.9	24.8	24.6	41.1	73.9	29.0	233.0	41.1	3.5
1992	22.2	9.0	17.4	0.2	2.9	24.9	24.6	40.9	73.5	29.0	235.0	40.9	0.5
1993	21.9	8.7	17.8	0.2	2.9	25.0	24.6	40.7	75.4	29.0	237.0	40.7	0.5
1994	21.7	8.5	17.8	0.2	2.9	28.9	24.6	41.1	73.3	29.0	239.0	41.1	0.5
1995	23.0	8.2	16.8	0.2	2.9	32.7	24.6	40.9	73.5	29.0	241.0	40.9	0.5
1996	22.1	7.9	15.4	0.2	2.9	36.6	24.6	41.3	72.8	29.0	243.0	41.3	0.5
1997	22.6	7.7	16.7	0.2	2.9	40.4	24.6	40.7	73.8	29.0	245.0	40.7	0.5
1998	22.7	7.4	16.3	0.2	2.9	44.3	24.6	41.6	74.1	29.0	247.0	41.6	0.5
1999	22.0	7.1	16.4	0.2	2.9	48.1	24.6	41.2	73.0	32.1	249.0	41.2	0.5
2000	22.1	7.1	18.5	0.2	2.9	52.0	24.6	39.8	74.5	36.9	251.0	39.8	0.4
2001	22.0	7.0	16.9	0.2	2.9	51.6	24.6	41.1	72.2	41.7	251.0	41.1	0.4
2002	24.1	6.8	16.4	0.2	2.9	51.3	24.6	40.4	72.8	46.6	223.3	40.4	0.3
2003	22.0	6.6	16.6	0.2	2.9	50.9	24.6	41.0	73.0	51.4	195.7	41.0	0.3
2004	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	56.3	168.0	41.0	0.3
2005	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	61.1	140.0	41.0	0.3
2006	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	65.9	140.0	41.0	0.2
2007	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	70.8	140.0	41.0	0.2
2008	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	75.6	140.0	41.0	0.3
2009	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	80.5	140.0	41.0	0.2
2010*	22.0	6.4	17.4	0.2	2.9	50.5	24.6	41.0	73.0	85.3	140.0	41.0	0.2

- Sales of Electronic Products to Residential and Commercial Sectors –

For many product categories, the patterns of use, storage, and end-of-life management of electronic products are likely similar across residential and commercial sectors. However, for desktop CPUs, portables, hard-copy devices, and computer displays, commercial establishments follow different patterns of use, storage, and end-of-life than residential households, as indicated in the lifespan estimates discussed on page 14.

Consequently, it is important to distinguish between residential and commercial sales for these product categories.

We used multiple sources to develop historical estimates of the shares of commercial and residential computer products sold in each model year. Our estimates and the data sources we used for each product category are shown in Table 3 below.[2]

Table 3: Data sources for estimates of residential and commercial electronic product sales shares, by product category and type

Category	Product Type	Model Year	Assumed Commercial Share of Sales (by units)	Assumed Residential Share of Sales (by units)	Source of Assumption
Computers	Desktop CPUs	1980-1992	70%	30%	Gartner (2001)
		1993-2005	Ranges from 58% to 68%	Ranges from 32% to 42%	Gartner (2001); Vokes (2009)
		2006-2010	Ranges from 61% to 68%	Ranges from 32% to 39%	IDC (2009); Vokes (2009)
	Portables	1980-1992	100%	0%	Assumed no residential sales of portables.
		1993-2006	Ranges from 55% to 100%	Ranges from 0% to 45%	Gartner (2001); Vokes (2009)
		2007-2010	45%	55%	Based on average of 2002-2006 residential sales shares.
Hard-copy devices	Hard-copy devices	1980-1992	90%	10%	Assumes same residential sales share as in 1992.
		1992-2010	Ranges from 40% to 90%	Ranges from 10% to 60%	Gartner (2001) and Vokes (2009); residential sales share for fax machines is taken from Appliance Magazine (2008) and Vokes (2009); residential sales for scanners in 1997 are based on Guo et al. (1998), and Vokes (2009) assumes that 100% of growth in scanner sales from 1997 is residential.
Displays	PC CRT monitors	1980-2010	Ranges from 58% to 70%	Ranges from 30% to 42%	Assumed residential sales are equal to residential sales share for desktop PCs
	PC flat panels	1989-1997	70%	30%	Assumption, based on residential sales share in 1998
		1998-2010	Ranges from 58% to 68%	Ranges from 32% to 42%	Assumed residential sales are equal to residential sales share for desktop PCs

[2] The 2008 report assumed that a fixed share (62 percent) of all desktop CPUs, portables, hard-copy devices, and computer displays are sold to the residential sector (EPA 2008). The updated data sources in Table 3 show that the original assumption underestimated commercial sales across many product types, particularly in earlier model years.

- Use, Storage, and Total Lifespan of Electronic Products –

Before electronic products are sent to their end-of-life management, they are either in use or in storage. The total lifespan of electronic products is equal to the amount of time they are in use plus the period of time they are stored before their end-of-life management. We first developed assumptions of the total lifespans of electronic products in order to estimate the number of electronic products at end-of-life each year. Next, we developed assumptions of how long products remain in use before being stored in order to estimate the number of products kept in storage each year.

Our lifespan assumptions are shown in Table 4 for residential products and in Table 5 for commercial products. The bar graphs below each table translate this information into the average age at which each product type is sent for their end-of-life management. These tables show the cumulative percentage of each product type ready for end-of-life management at a given age. For example, we assume that 20 percent of mobile devices are ready for their end-of-life management when they are two years old. When they are five years old, we assume an additional 70 percent of mobile devices are at their end-of-life. Consequently, 20 plus 70 percent, or 90 percent of all mobile devices in a given model year have been sent for their end-of-life management at five years of age. The remaining 10 percent are sent for their end-of-life management five years later, resulting in 100 percent of the products sent for their end-of-life management after ten years. This section details the data sources used to develop the lifespan assumptions shown in Table 4 and Table 5.

First, we searched for new and updated information on product lifespans. While several sources of lifespan data were found, none were definitive.[3] The most comprehensive source we located remained the Florida DEP's electronic products brand distribution database (2009). Although the Florida DEP Web site was last updated in 2009, the brand distribution dataset has not been updated since 2006.

For desktop CPUs, portables, hard-copy devices, and computer displays it is likely that use, storage, and disposal patterns are different between residential and commercial sectors. As a result, we developed separate commercial-sector lifespan assumptions for these categories. Based on information from the International Association of Electronics Recyclers (IAER 2006), surveys of computer reuse (Lynch 2001), personal communications with industry experts (DuBravac 2006, Powers 2006), and assumptions about the length of time that commercial products are held in storage, we assumed that 40 percent of commercial computers reach their end-of-life after three years, another 40 percent after five years, and the remaining 20 percent after seven years.

Second, we used data from literature and industry experts to develop assumptions of the period of time that the following electronic products remain in storage before their end-of-life management:

- We assumed that residential desktop CPUs, hard-copy devices, and computer monitors are kept in use for an average of seven years before entering storage (Matthews 2003, IAER 2006),
- Residential portables remain in use for six years on average before storage (DuBravac 2005),
- CRT TVs are kept in use for 11 years before entering storage (DuBravac 2005), and
- Mouse, keyboards, flat-panel TVs, and projection TVs are not stored before their end-of-life management.

Finally, we developed[4] storage estimates for mobile devices and for commercial computers, hardcopy devices, and computer monitors based on the following sources:

[3] We compared assumptions used in the 2008 report with these other data, and came to the conclusion that, for most products, existing assumptions were reasonable and should be kept.

[4] The 2008 report did consider commercial storage of electronics products.

- We assumed that commercial desktop CPUs, portables, hard-copy devices, and computer monitors are kept in use for three to five years, after which 20 percent are stored for up to two additional years. We believe a two-year storage estimate is conservative, but reflects the fact that commercial businesses are less likely than residential users to store products for long periods of time.

  This assumption is based on evidence that storage occurs in commercial institutions: twenty percent of the participants in a 2005 survey of U.S. commercial institutions indicated they kept PC assets that were ready for disposal (Daoud 2007). The survey results reflect the number of companies that said they store electronic products—they do not indicate the number or percentage of products stored.

- We assumed that 20 percent of mobile devices are at their end-of-life at the end of two years, with an additional 70 percent sent to their end-of-life management at the end of five years. These assumptions are based on Moss (2010). We also assume that the remaining 10 percent of mobile devices are stored up to a total of 10 years, based on estimates from Niera (2006) and Singhal (2005) that phones can be kept in storage for up to 10 years.

Table 4: Cumulative percentage of each product type sent to end-of-life management at a given age for residential products. *Average life of each product type shown in bar chart.*

Age (years)	RESIDENTIAL ELECTRONIC PRODUCTS												
	Computers		Computer Peripherals			Computer Displays		Televisions					Mobile devices
	Desktop CPUs	Portables	Hard-copy devices	Mice	Keyboards	PC CRT monitors	PC flat panels	CRT TVs < 19"	CRT TVs >= 19"	Flat-panel TVs	Projection TVs	Monochrome TVs	
0													
1													
2													20%
3													
4		20%	25%										
5		35%		100%	100%	25%							90%
6		55%											
7	25%	100%	50%						25%				
8						50%		25%			100%	25%	
9							100%			100%			
10	50%		75%			75%							100%
11													
12									50%				
13						100%		50%				50%	
14	75%		100%										
15									75%				
16													
17								75%				75%	
18	100%												
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21													
22													
23								100%				100%	

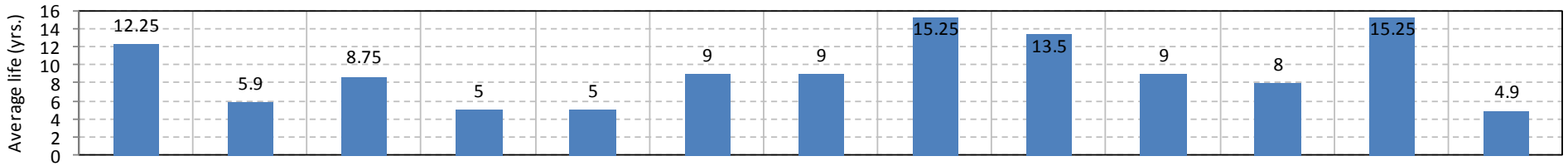
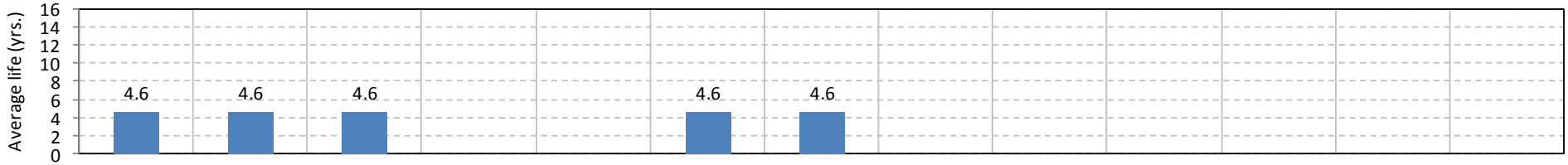


Table 5: Cumulative percentage of each electronic product type sent to end-of-life management at a given age for commercial products. *Average life of each product type shown in bar chart.*

Age (years)	COMMERCIAL ELECTRONIC PRODUCTS												
	Computers		Computer Peripherals			Computer Displays		Televisions					Mobile devices
	Desktop CPUs	Portables	Hard-copy devices	Mice	Keyboards	PC CRT monitors	PC flat panels	CRT TVs < 19”	CRT TVs >= 19”	Flat-panel TVs	Projection TVs	Monochrome TVs	Mobile devices
0				Not applicable	Not applicable			Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
1													
2													
3	40%	40%	40%			40%	40%						
4													
5	80%	80%	80%			80%	80%						
6													
7	100%	100%	100%			100%	100%						



Not applicable = We did not distinguish between residential and commercial products for these categories.

- End-of-life Management –

Electronic products at their end-of-life are managed by one of two end-of-life management practices: they are either collected for recycling (they may then be subsequently reused, refurbished, or recycled for materials recovery), or disposed in landfills or waste-to-energy incinerators (see Figure 1). For this report, we updated our estimates of the number of end-of-life electronic products that are collected for recycling to incorporate state reports on mandated electronics collection programs and results from our survey of recyclers. The advantages of this updated approach are that it incorporates a greater amount of hard data (from state-mandated collection programs and from electronic product recyclers), and provides a framework for refining future estimates as better data become available. A detailed explanation of this approach is provided in Appendix D.

First, we estimated the total quantity of electronic products collected for recycling from residential sources. For states where data were available, we compiled reports on the quantity of electronic products collected through state-mandated collection programs. The product types covered by electronics recycling laws and the methods for reporting the quantity of electronic products collected vary from state to state. In 2009, information was available from eight states representing approximately 29 percent of the U.S. population.[5] Electronic products are collected through various municipality or manufacturer sponsored programs in the other 42 states in varying amounts, but reporting is not in place. States with low levels of collection report approximately one pound per capita; states with higher levels of collection report three to six pounds per capita. Based on this range, we assume one pound of electronic products collected per capita from residential sources in states that do not have electronics recycling laws or reporting in place.

Assuming one pound collected for recycling means that states that do not have electronics recycling laws or reporting in place collect amounts roughly equivalent to states reporting low levels of collection, and between one third to one sixth the per-capita rate of states reporting higher levels of per-capita collection.

To account for the quantity of electronic products collected from commercial sources, we assumed that 67 percent of the electronic products collected for recycling come from commercial sources, based on results from the survey of recyclers.[6] For states where commercial electronics were not included in reported amounts collected (i.e., all states except California), we back-calculated total collection for recycling from the quantity of residential products collected, assuming that commercial recycling accounted for 67 percent of the electronic products collected.

Table 6 provides the estimated quantity of electronic products collected for recycling using this approach and compares it to our 2008 report. The updated method in this report estimates approximately 25 to 30 percent higher tonnage of collection for recycling. We believe the variation in collection for recycling results primarily from improvements to the methodology in estimating the amount of used electronics sent for recycling, rather than changes in actual hard data that accounts for the tonnage collected for recycling. Due to the lack of robust data that is currently available, there is still a high level of uncertainty in the actual quantity of electronics collected for recycling.

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[5] Data compiled from California (NERIC 2009), Delaware (NCER 2010), Maine (Maine DEP 2008), Maryland (MDE 2007), Minnesota (Minnesota PCA 2009; Linnel 2009), Oregon (Oregon E-cycles 2008), Washington (Washington MMFA 2010), Texas (Texas Campaign for the Environment 2010), and Virginia (NCER, NERC 2010; Virginia DEQ 2010). Not all states provided data for all years; Maryland provided data only in 2006 and 2007, Minnesota only in 2007 – 2009, and Washington, Oregon, Texas, and Virginia only in 2009.

[6] We estimated the commercial share by multiplying the total tonnage of specified consumer electronics processed by each recycler by the percentage of commercial recovery reported by that recycler. We then summed the calculated commercial tonnage from all recyclers, and divided this by the total amount processed by all of the recyclers to calculate the average commercial share. We averaged this result across 2007, 2008, and 2009 to calculate the 67-percent share of commercial recycling.

Table 6: Estimated quantity of electronic products collected for recycling

Year	Estimate Used in This Report (short tons)	EPA 2008 (short tons)
2006	470,000	377,000
2007	551,000	414,000

Second, we estimated the quantity of each product type collected for recycling. To develop an estimate of the number of mobile devices collected for recycling, we conducted a survey of mobile device recyclers (see the Survey of Recyclers section). Based on the number of mobile devices collected for recycling and the self-estimated market share of the largest of the recyclers, we estimated the total number of mobile devices collected for recycling in 2007 through 2009 (i.e., the total recycling market). Our calculations suggest that 8.3 million devices, or seven percent of mobile devices at end-of-life, were collected for recycling in 2007, increasing to 11.8 million, or an eight-percent rate of collection for recycling, in 2009.[7]

We then used a growth trend in mobile devices collected from 2006 through 2008 to forecast the survey results to 2010, based on information from mobile device manufacturers and carriers. The estimate of the number of mobile devices collected for recycling has a high degree of uncertainty, due to a limited dataset and a lack of knowledge about the true market shares of individual recyclers.

To estimate the number of other electronic products collected for recycling, we subtracted the estimated quantity of mobile devices collected from the total quantity of electronic products collected for recycling. We assumed that each product was collected in a proportion based on the average composition across a survey of seven electronics recyclers that collect products from a representative mix of residential and consumer sources.[8] This percent breakdown is shown in Table 7.

Table 7: Types of electronic products collected, by percent of total weight collected for recycling in 2009. *These data are based on a survey of recyclers that was conducted for this report (see the Survey of Recyclers section).*

Category	Average composition of electronic products collected for recycling (not including mobile devices)
Computers (desktop CPUs and portables)	26%
Computer displays (CRT and flat-panel monitors)	30%
Hard-copy devices	15%
Mice and Keyboards	1%
TVs (CRT, flat-panel, and projection TVs)	28%
Total	100%

[7] Our 2008 report assumed that 10 percent of mobile devices were collected for recycling, based on personal communications with experts (EPA 2008).

[8] See the Survey of Recyclers section for details. Seven recyclers participated in the survey; three of the recyclers received more than 80% of the total quantity collected for recycling from residential sources and the remaining 20% from commercial sources, one received 40% from residential sources and 60% from commercial sources, and three received less than 15% from residential sources and over 85% from commercial sources. Consequently, the results from this survey are representative of an average mix of residential and commercial products.

Survey of Recyclers

In an effort to collect additional data to determine what happens to electronic products collected for recycling, we conducted a survey of electronics recyclers. Seven recyclers participated in the survey, representing a geographically-dispersed subset of recyclers in the United States. We requested annual data on the quantity of electronic products processed by each company in both tonnage and number of products, for all the electronic products included in the scope of this report. On average, 93 percent of the electronic products that these companies collect from year to year fall within the category of "consumer electronics" as we have defined it in the introduction of this report. We did not collect information on exports of end-of-life electronics. Companies were also asked to estimate their market share, a percentage breakdown of how electronic products are managed, and the source (residential vs. commercial) of the electronics. This survey was conducted during the autumn of 2009.

After products are collected for recycling and delivered to recyclers, there are three possible outcomes: products may be reused or refurbished, recycled, or disposed. As shown in Table 8, the seven recyclers that participated in the survey recycled close to 70 percent of the electronic products they received, while 30 percent were reused. Only a small fraction—less than one percent of the products collected for recycling—was ultimately disposed. While computers make up the majority of the products reused and refurbished, the recyclers we surveyed indicated that they refurbished other types of products as well, including TVs and hard-copy devices.

Most of the companies surveyed were not able to provide enough information on their individual market share based on knowledge of their market, so a useful estimate of the U.S. market could not be calculated. Some companies lacked any estimates of their market share, while others based their market share on an estimate in an EPA document; both of these prevented the collection of sufficient data.

Table 8: Results of Electronics Recycling Survey

	2007	2008	2009
Total tons of consumer electronic products collected for recycling by recyclers included in survey*	77,779	82,561	85,387
Average percent			
Reused or refurbished	30%	32%	33%
Recycled	69%	68%	66%
Disposal	<1%	<1%	<1%

* Tons collected are adjusted from survey results: one company reported only for 2008 and 2009, and the quantity reported was much higher than for other companies, giving a misleading picture of inter-annual variability in electronics collection, so this company's results were omitted from this table. In addition, 2009 numbers have been adjusted upward from survey results, based on the number of months of data received for 2009 (12 months of data were not available in all cases).

We also conducted a second survey targeting three separate companies that specialize in managing used and end-of-life mobile devices. From each company, we collected the annual tonnage and number of electronic products processed for 2007 through 2009, average mobile device weight, a percentage breakdown of how mobile devices are managed, and the sources of end-of-life mobile devices (i.e., residential or commercial sources). We did not collect information on exports of end-of-life mobile devices. This survey was conducted in December of 2009 and January of 2010.

The results of the survey are presented in Table 9. The survey found that mobile devices are reused slightly more frequently than average, with 40 percent of devices collected for recycling entering reuse. According to the recyclers, 60 percent of mobile devices were recycled and none of the products collected for recycling were disposed.

Findings from both surveys are incorporated into the model's assumptions about their end-of-life management.

Table 9: Results of Mobile Devices Recycling Survey

	2007	2008	2009
Total tons of mobile devices collected for recycling by recyclers included in survey *	561	924	743
Average percent			
Reused or refurbished	42%	43%	38%
Recycled	58%	57%	62%
Disposal	0%	0%	0%

* Tons collected are adjusted from the survey results: 2009 numbers have been adjusted upward from survey results, based on the number of months of data received for 2009 (12 months of data were not available in all cases).

3. Results

We used the methodology and data sources discussed in Chapter 2 to model the following aspects of electronic waste management in the United States:

- The number of units and tonnage of electronic products that are ready for end-of-life management by year;
- The number and tonnage of electronic products that are either collected for recycling or disposed; and
- The number and tonnage of electronic products that are in use and in storage.

Figure 4 presents the quantity of electronic products ready for end-of-life management in each year between 1990 and 2010. We estimate that 2.37 million short tons of electronic products were ready for end-of-life management in 2009. This represents a 122-percent increase in the quantity of discarded electronics from1999.

Of the electronic products that are ready for their end-of-life management, Figure 5 presents the quantities that are collected for recycling and the quantities sent for disposal to landfills or waste-to-energy incinerators. We estimate that the percentage of electronic products collected for recycling has increased from 22 percent in 2006 to 25 percent in 2009, with a 27-percent rate projected for 2010. This would represent an increase in recycling of 179 thousand short tons from 2006.

The annual quantities from 2006 through 2010 of each electronic product ready for end-of-life management, collected for recycling, and disposed of are presented in Tables 10, 11, and 12, respectively. Based on this information, Table 13 calculates the rate at which individual electronic products are collected for recycling. Computers, hard-copy devices, and computer displays have the highest rates of collection for recycling; we estimate that 38, 34, and 29 percent of these products, respectively, were collected for recycling in 2009, relative to the total weight of each product ready for their end-of-life management. We estimate that mobile devices have the lowest rate of collection (excluding keyboards and mice). The calculated rate of mobile devices collected for recycling varies more significantly from year to year compared to other product types due to the lack of reliable data on the quantity of mobile devices collected for recycling.

Figure 6 presents the quantity of electronic products that were still in use or in storage in 2009, of all products sold between 1980 and 2009. In total, we estimate that five million short tons of electronic products are in storage. See Table 14 for the full results.

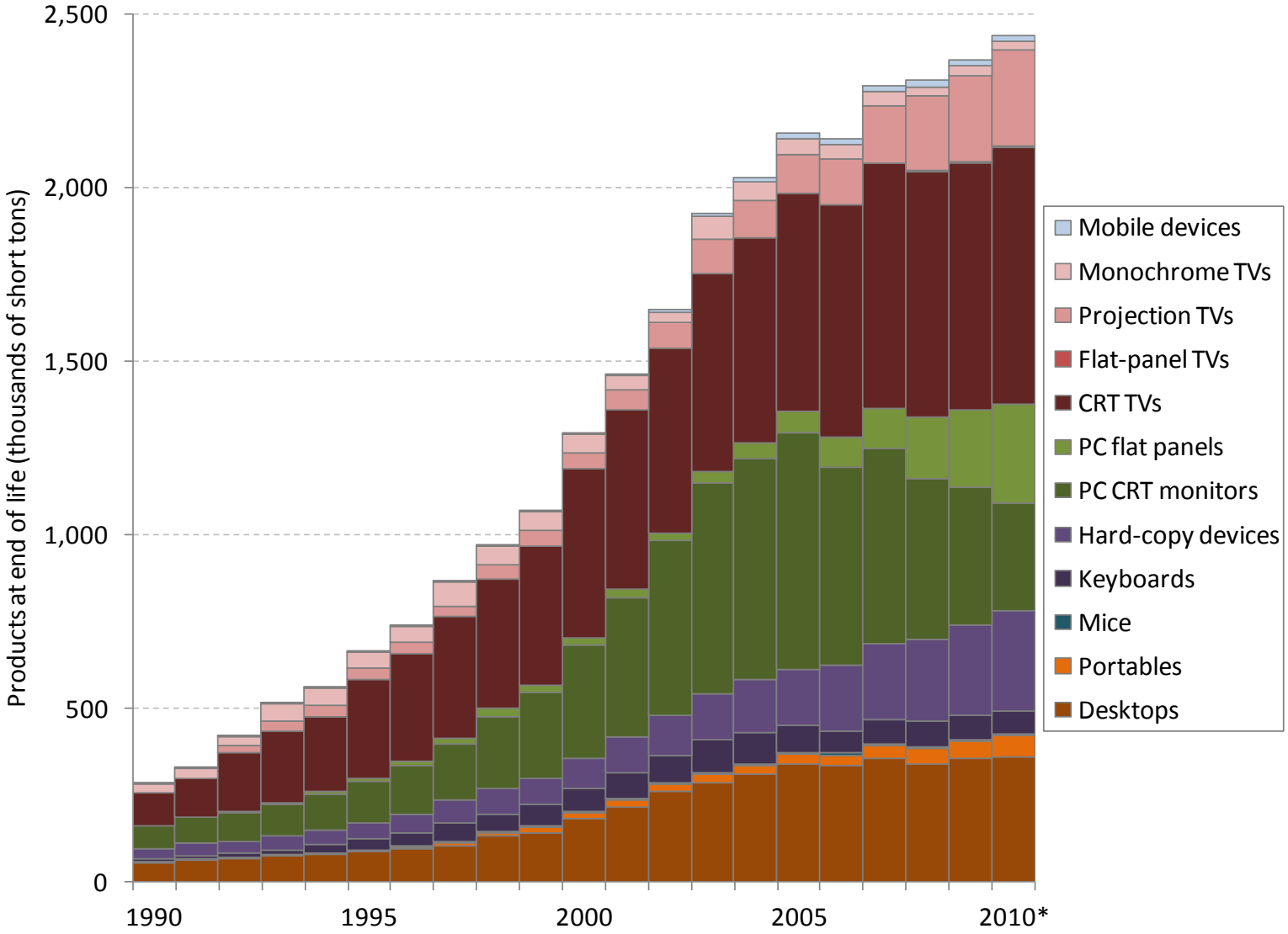

Figure 4: Quantity of electronic products ready for end-of-life management in the United States. **Results for 2010 are projected based on estimates from previous years.*

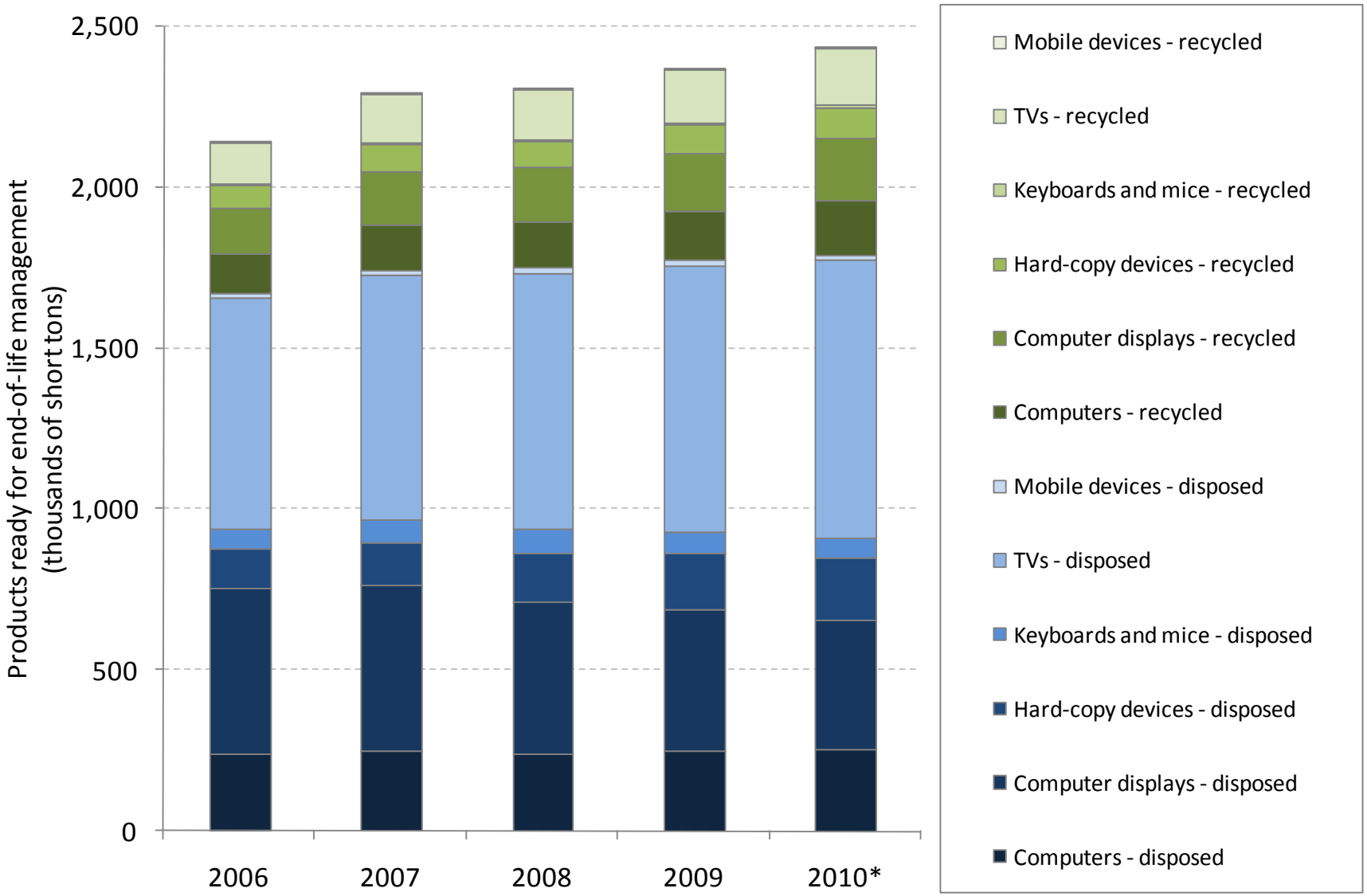

Figure 5: Quantity of electronic products collected for recycling or disposed, by year. **Results for 2010 are projected based on estimates from previous years.*

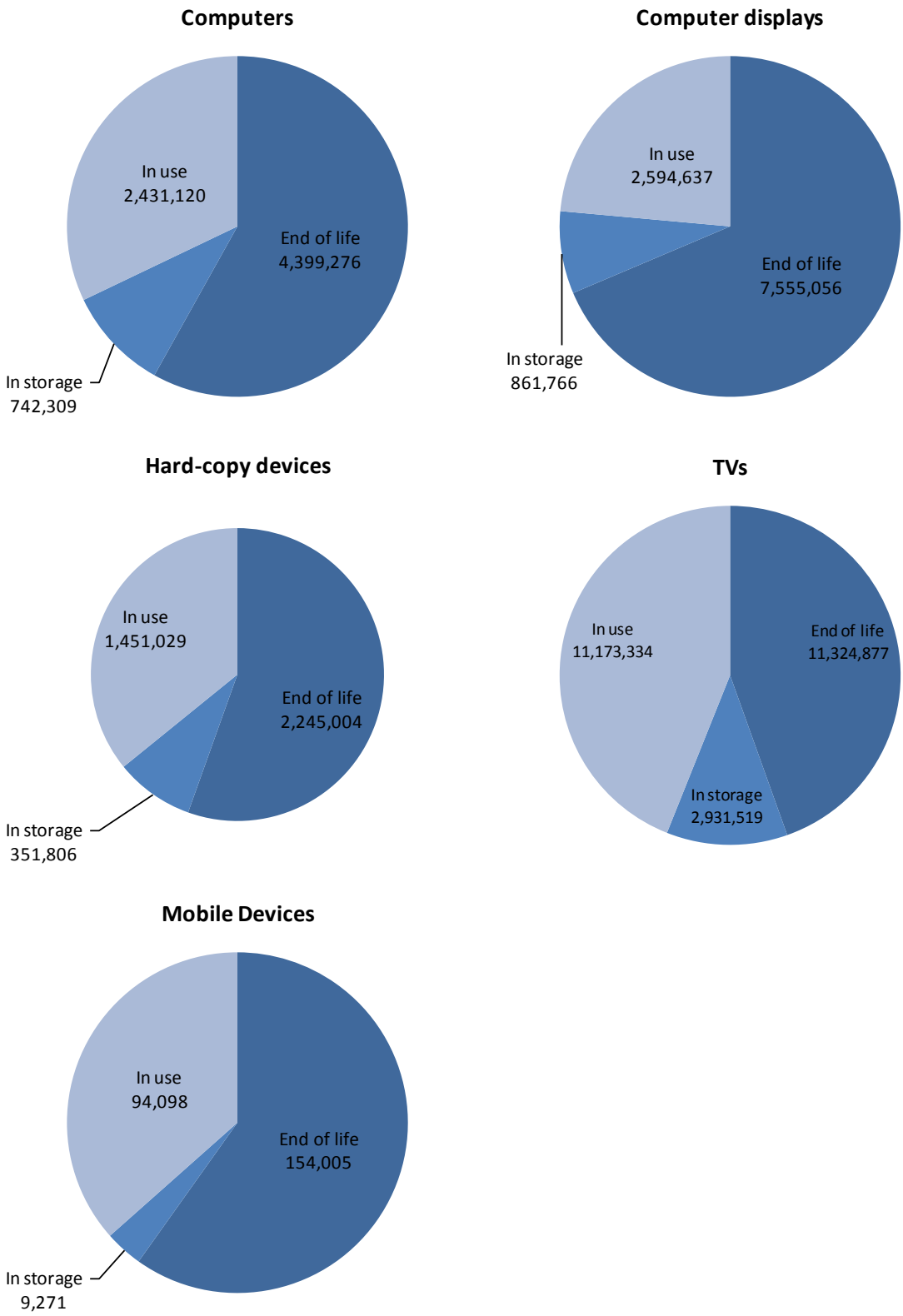

Figure 6: Quantity of products in use, storage, or end-of-life management in 2009, out of all electronic products sold between 1980 through 2009, in short tons.

Table 10: Electronic products ready for end-of-life management from 2006 to 2010. *Results are projected for 2010 based on estimates from previous years.*

Electronic products ready for end-of-life management														
	Computers		Computer displays		Hard-copy devices		Keyboards and mice		TVs		Mobile devices		Total	
Year	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	Units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons
2006	39,400	365,000	31,000	656,000	23,000	190,000	96,800	68,800	25,700	847,000	100,000	16,900	316,000	2,140,000
2007	42,500	393,000	32,800	679,000	25,200	218,000	106,000	76,200	26,900	911,000	118,000	18,400	351,000	2,300,000
2008	44,500	384,000	33,600	642,000	27,700	235,000	88,200	78,000	27,000	951,000	134,000	19,200	355,000	2,310,000
2009	47,400	407,000	34,300	618,000	30,700	262,000	86,600	72,400	27,200	993,000	141,000	18,800	367,000	2,370,000
2010	51,900	423,000	35,800	595,000	33,600	290,000	82,200	67,800	28,500	1,040,000	152,000	19,500	384,000	2,440,000

Table 11: Products collected for recycling from 2006 to 2010. *Results are projected for 2010 based on estimates from previous years.*

Electronic products collected for recycling														
	Computers		Computer displays		Hard-copy devices		Keyboards and mice		TVs		Mobile devices		Total	
Year	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons
2006	13,200	122,000	6,650	141,000	8,520	70,300	6,590	4,690	3,980	131,000	5,590	940	44,500	470,000
2007	15,400	143,000	7,960	165,000	9,520	82,400	7,650	5,490	4,540	154,000	8,300	1,300	53,400	551,000
2008	16,700	144,000	8,730	167,000	9,820	83,300	6,280	5,560	4,410	156,000	14,300	2,050	60,200	558,000
2009	18,000	154,000	9,900	178,000	10,400	89,100	7,100	5,940	4,560	166,000	11,800	1,570	61,800	595,000
2010	20,600	168,000	11,700	194,000	11,200	97,000	7,830	6,460	4,940	181,000	17,400	2,240	73,700	649,000

Table 12: Products disposed from 2006 to 2010. *Results are projected for 2010 based on estimates from previous years.*

Electronic products disposed														
	Computers		Computer displays		Hard-copy devices		Keyboards and mice		TVs		Mobile devices		Total	
Year	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons
2006	26,300	243,000	24,400	515,000	14,500	120,000	90,200	64,100	21,700	716,000	94,700	15,900	272,000	1,670,000
2007	27,000	250,000	24,900	514,000	15,600	135,000	98,500	70,700	22,400	757,000	110,000	17,100	298,000	1,740,000
2008	27,800	240,000	24,900	475,000	17,900	152,000	81,900	72,500	22,600	796,000	120,000	17,200	295,000	1,750,000
2009	29,400	252,000	24,400	440,000	20,300	173,000	79,500	66,500	22,700	827,000	129,000	17,300	306,000	1,780,000
2010	31,300	255,000	24,100	401,000	22,400	193,000	74,400	61,400	23,600	864,000	135,000	17,200	310,000	1,790,000

Table 13: Rate at which electronic products are collected for recycling relative to the total weight of each product ready for end-of-life management, 2006 to 2010. *Results are projected for 2010 based on estimates from previous years.*

Year	Computers	Computer displays	Hard-copy devices	Keyboards and mice	TVs	Mobile devices	Total
2006	33%	21%	37%	7%	16%	6%	**22%**
2007	36%	24%	38%	7%	17%	7%	**24%**
2008	38%	26%	35%	7%	16%	11%	**24%**
2009	38%	29%	34%	8%	17%	8%	**25%**
2010	40%	33%	33%	10%	17%	11%	**27%**

Note: the rate at which mobile devices are collected for recycling varies more significantly from year to year, compared to other product types, because of variation in both actual collection of mobile devices, as well as the quality of collection reporting.

Table 14: Total products at end-of-life, in storage, and in use in 2009, out of all products sold between 1980 and 2009.

	Computers		Computer displays		Hard-copy devices		Keyboards and mice		TVs		Mobile devices		Total	
	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons	units ('000s)	short tons
Total sold 1980–2009	857,00	7,570,000	653,000	11,000,000	471,000	4,050,000	1,670,000	1,460,000	772,000	25,400,000	1,660,000	257,000	6,090,000	49,800,000
In use	325,00	2,430,000	191,000	2,590,000	167,000	1,450,000	368,000	311,000	312,000	11,200,000	812,000	94,000	2,170,000	18,100,000
Residential storage	57,900	632,000	31,900	714,000	34,300	292,000	Not estimated	Not estimated	104,000	2,930,000	57,800	9,270	286,000	4,580,000
Commercial storage	12,600	111,000	8,300	148,000	7,090	60,300	Not estimated	Not estimated	Not estimated	Not estimated	Not estimated	Not estimated	28,000	319,000
Total storage	70,500	742,000	40,200	862,000	41,400	352,000	Not estimated	Not estimated	104,000	2,930,000	57,800	9,270	314,000	4,900,000
At end-of-life	462,000	4,400,000	422,000	7,560,000	262,000	2,250,000	1,310,000	1,150,000	356,000	11,300,000	789,000	154,000	3,600,000	26,800,000

4. Discussion

The results presented in Chapter 3 provide a broad overview of the management of electronic products in the United States. Below we discuss the findings, trends, and comparisons resulting from the study, and limitations and uncertainties in the results.

Findings, Trends, and Comparisons

This report provides important insights into the electronic products market and its implications for the management of used electronics. The following findings and trends were identified in the sale, storage, quantity of used electronic products, and the end-of-life management of electronic products:

- In the last 10 years, the sales share of flat-panel displays has increased relative to CRT displays, and flat-panel TVs have become larger and heavier over the same period. The model reflects these trends, estimating that flat-panel displays now constitute a sizable and growing share of used electronics ready for end-of-life management. Conversely, the quantity of CRT TVs is estimated to have remained relatively constant between 2005 and 2010, and the quantity of CRT monitors has already noticeably decreased, since CRT monitors have a shorter average lifespan than TVs.
- On June 12, 2009, all full-power television stations in the United States began broadcasting exclusively in a digital format. With this switch, many Americans were required to obtain either an analog-to-digital converter box or a new digital-ready TV. The effect the digital switch had on the volume of TVs assigned for end-of-life management has been unclear because there was no concrete data available.
- Of the 2.44 million short tons of electronic products that we project will be ready for end-of-life management in 2010, CRT TVs and CRT monitors constitute 43 percent by weight.
- CRT TVs and CRT monitors constitute a smaller proportion of products ready for end-of-life management in 2010 because of the large number of cell phones and other mobile devices.
- The estimated share of electronic products collected for recycling suggests that collection for recycling, as a percentage of total electronic products at end-of-life in each year, has increased steadily from 22 percent in 2006 to 25 percent in 2009. We estimate that the average annual increase in the quantity of electronic products collected for recycling was nine percent over this time period. Extrapolating this growth rate to 2010, we estimate that 27 percent of electronic products could be collected for recycling (by weight), although there is considerable uncertainty in our estimate of the rate of electronics collected for recycling.
- Although our results reflect recent trends in the increasing quantities of electronic products collected for recycling, this amount could increase further if major electronics recycling programs that are starting in 2010 achieve the collection targets that they have recently established. For example, the Illinois Environmental Protection Agency has set a statewide goal to collect 16,000 short tons in 2010 (roughly 2.5 pounds per capita) (Illinois EPA 2010); the Wisconsin Department of Natural Resources (2010) estimates it will collect between 15 and 18 million pounds in the first half of 2010 by targeting 80% of covered electronic products sold to households and public schools (K to 12), and Indiana has set a target of collecting 60% of covered electronic products sold to households starting in April 2010 (Recycle Indiana, 2010).
- Although they contribute less than 0.5 percent of the total weight of electronic products collected for recycling, we estimate that mobile devices represent 20 to 25 percent of the individual units collected for recycling based on results from the survey of recyclers and information from mobile device manufacturers and carriers. While they are small in weight and size, there are substantial opportunities for collecting a large number of mobile devices.

- Of the electronic products sold from 1980 through 2009 that have not yet reached end-of-life management, we estimate that 74 percent of monochrome TVs were in storage in 2009. Sixty-one percent of PC CRT monitors were in storage, and 35 percent of CRT TVs. By comparison, we estimate that seven percent of mobile devices, or 57.8 million, were stored in 2009.
- We estimate that residential households currently store five times more computer products than are stored by commercial establishments, by weight. In total, we estimate that roughly 1.5 million short tons of computers, computer displays, and hard-copy devices were stored by residential households in 2009, while approximately 300,000 short tons were stored by commercial establishments.

The changes from the 2008 report are summarized in Table 15. Some differences between the results presented in the 2008 report and the results from this analysis can be explained by the updates to sales, storage, recycling, and weight data. However, there are a few larger discrepancies that are important to discuss:

- This report estimates that a much larger *weight* of computer products were collected for recycling in 2007 even though fewer *products* were collected for recycling relative to the 2008 report. In the 2008 report, the computer products category included mice and keyboards (which have a low weight-per-unit). Additionally, the 2008 report assumed that products are collected for recycling according to the share that they are present in their end-of-life; as a result, keyboards and mice represented a large portion of the estimated number of products collected for recycling.

  In this analysis, however, data obtained from the survey of recyclers was used to estimate the composition of electronic products collected for recycling. The survey showed that keyboards and mice contribute only a small fraction (around one percent) of what is collected for recycling. As a result, heavier items, such as desktop CPUs, TVs, computer displays, and hard-copy devices make up most of what gets collected for recycling in our model. This explains why we predict a lower number of electronic products collected for recycling (i.e., very few keyboards and mice collected) and a higher weight of electronic products collected (i.e., a larger number of heavy electronic products) than in the 2008 report.
- This report includes storage estimates for mobile devices and for the commercial sector, which was not addressed in the 2008 report. As a result of this change, the number of devices in storage is 34 percent greater. We believe that this change has made the analysis more robust, since there is good evidence that some amount of storage in these sectors is common.
- This report estimates that far fewer TVs were collected for recycling in 2007 than the 2008 report did. The lower collection rate results from our assumption that TVs constitute 28 percent of the electronic products collected for recycling in this analysis, rather than 40 percent in the 2008 report. We updated this assumption based on results from the survey of recyclers, whereas the 2008 report simply assumed that TVs were collected for recycling according to the share that they are present at their end-of-life.
- This report estimates that fewer mobile devices were collected for recycling in 2007 than the 2008 report. In the 2008 report, we assumed a constant collection rate of 10 percent for mobile devices; in this report, we updated this assumption based on the quantity of devices received by recyclers based on the recyclers survey, and extrapolated these results from the trend in collection for recycling of mobile devices from retailer data collected from mobile device manufacturers and carriers. This approach suggests that slightly fewer mobile devices are collected for recycling than previously estimated. We believe that this approach provides a more realistic estimate than the assumption used in the 2008 report.

The percent differences shown in Table 15 are only valid relative to the same management practice for each electronic product, and are not comparable across rows. For example, Table 15 shows that there is a large percentage increase in collection for recycling of computer products (by weight), but only a small percentage decrease in disposal as compared to the results for 2007 from the 2008 report. This is because a much smaller quantity of products (by weight) are collected for recycling, so an increase in collection for recycling produces a larger percentage change. Since a larger quantity of material is disposed of, the same reduction in the quantity produces a much smaller percentage change.

Table 15: Percent change in the estimates of electronic products collected for recycling versus disposal for 2007 by this report relative to the 2008 report.

Management Practice	Computer Products		TVs		Mobile Devices		Total	
	units	short tons	units	short tons	units	short tons	units	short tons
Ready for end-of-life management	0.5%	3.3%	0.0%	0.0%	-16.0%	-4.1%	-5.7%	1.9%
Collected for recycling	-15.8%	62.1%	-28.0%	-8.5%	-40.9%	-32.5%	-22.1%	33.0%
Disposed of	5.5%	-10.0%	8.6%	1.9%	-13.3%	-1.0%	-2.1%	-5.1%

Note: The numbers reflect the percent change in the results of this report as compared to the 2008 report. Negative numbers mean that the results in this report were lower than those in the 2008 report. For example, compared to the 2008 report, this report estimates that 8.5 percent fewer short tons of TVs were collected for recycling.

Comparisons between this report and the 2008 report of the number of electronic products in 2007 ready for end-of-life management, collected for recycling, and disposed are illustrated in Figures 7, 8, and 9, respectively. Figure 10 shows the differences in the shares of electronic products in use and storage versus in end-of-life management for computer products and TVs sold from 1980 through 2007. For example, it illustrates that for 2007, the 2008 report estimated a higher number of computer products were in use and storage than the estimate from this report.

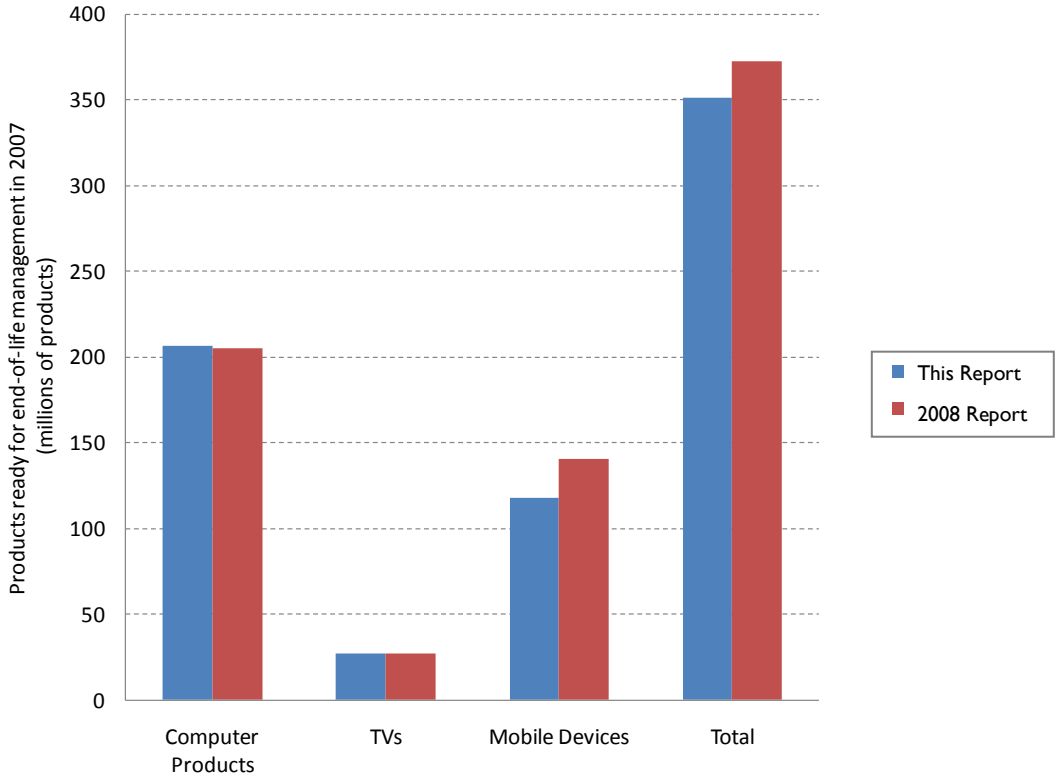

Figure 7: Comparison of electronic products ready for end-of-life management in 2007 in the 2008 report and this analysis. *Note that the vertical axis is in terms of the number of units.*

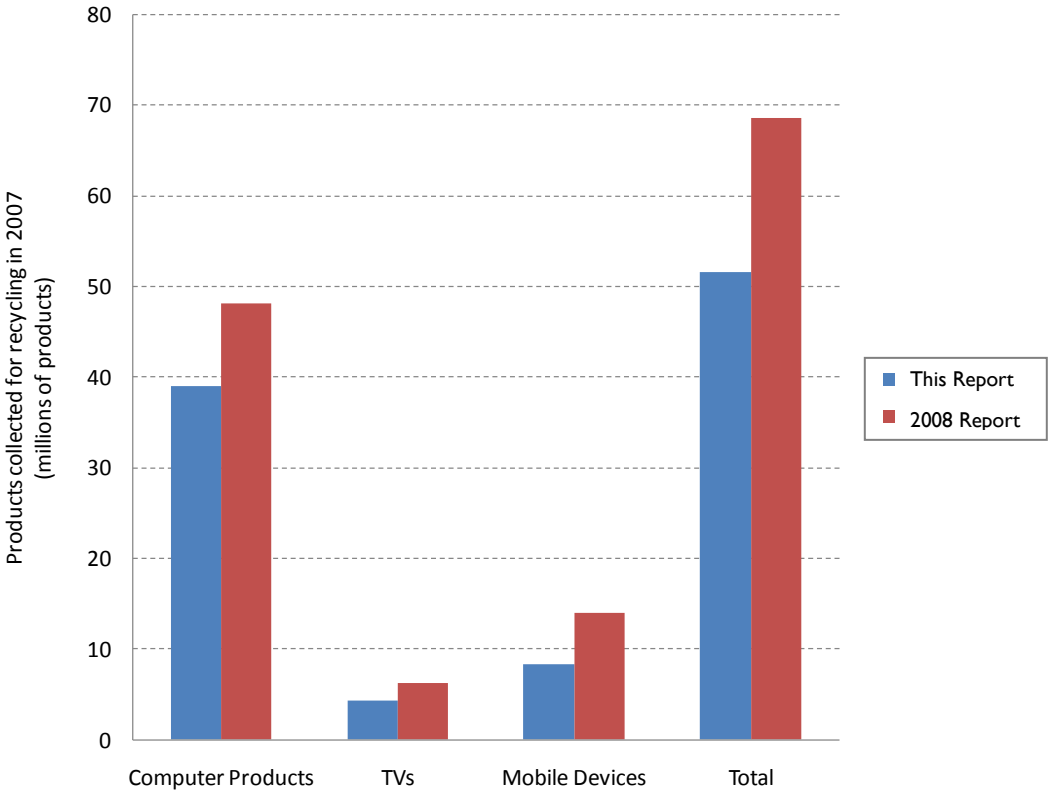

Figure 8: Comparison of electronic products collected for recycling in 2007 in the 2008 report and this analysis. *Note that the vertical axis is in terms of the number of units.*

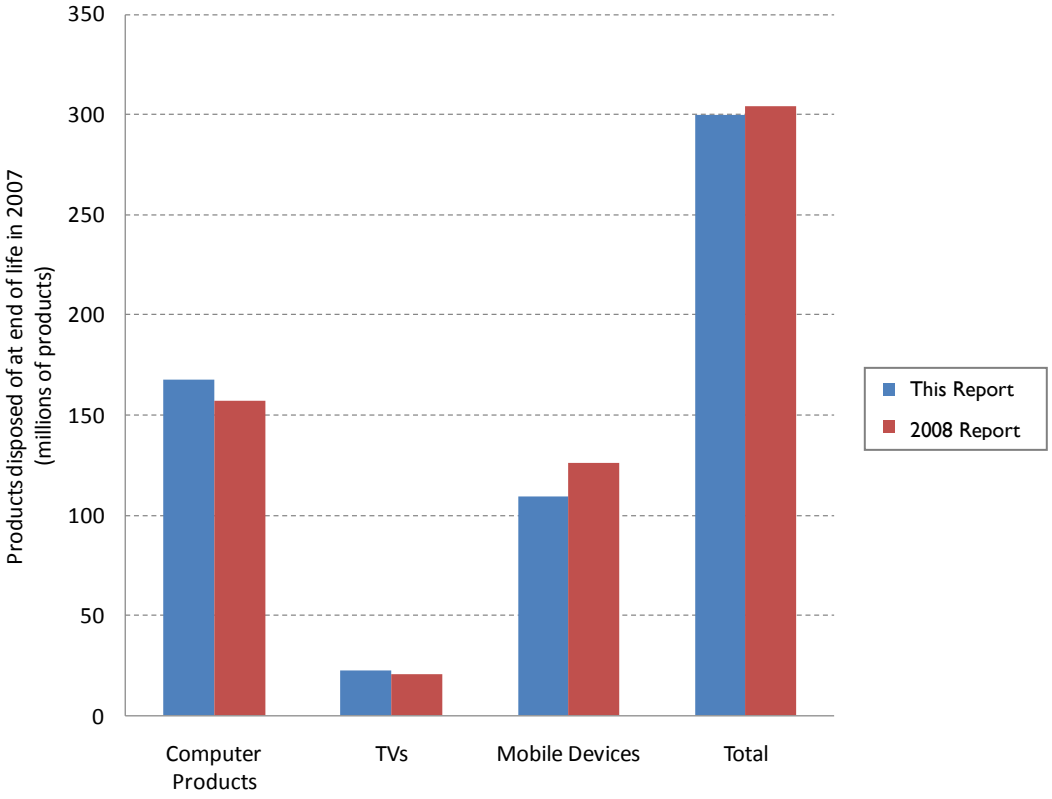

Figure 9: Comparison of electronic waste disposed in 2007 in the 2008 report and this analysis. *Note that the vertical axis is in terms of the number of units.*

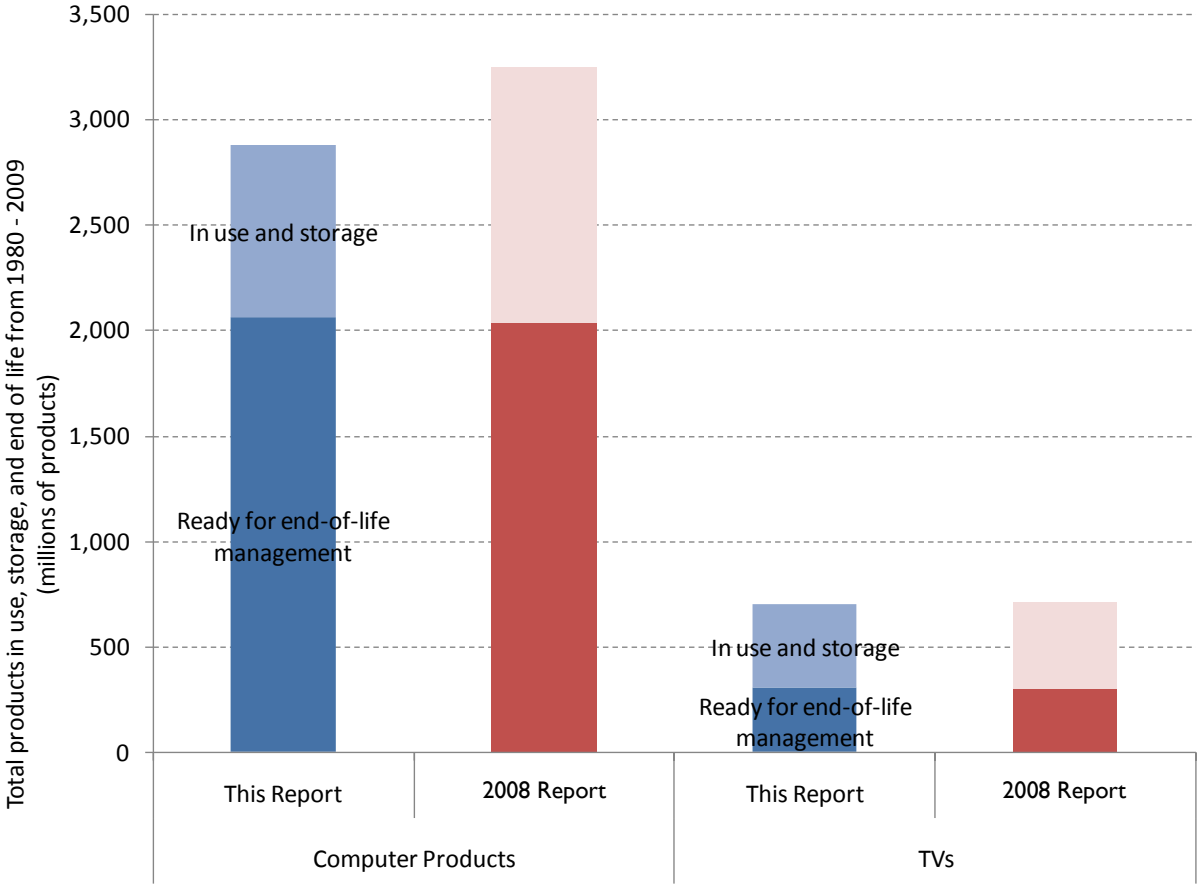

Figure 10: Comparison of the share of electronic products in use and storage versus in end-of-life management for all computer products and TVs sold from 1980 through to 2007.

Limitations and Uncertainties

This study was based on the best available data, but the world of electronics is one that is evolving at a rapid pace and is often not well characterized. There were some significant data limitations, which affected the robustness of this analysis. Important limitations and uncertainties are outlined below.

- Shipment data were used to estimate the number of electronic products sold. These data do not describe the number of products actually sold by retailers; however shipment data are a reasonable indicator of product sales.
- We calculated the simple-average weight for each product category across different model sizes. This approach may either overestimate or underestimate the actual product category weight, depending on whether smaller- or larger-sized models are sold more frequently in a product category. A more accurate approach would be to develop weighted averages based on the sales shares of various models within each product category; however, sufficient data was not available to develop weighted averages for the product categories in this report.
- Mobile device weights do not include smartphones or PDAs; they currently only reflect cell phone weights, based on data provided by *Consumer Reports*. Since smartphones and PDAs are likely to be somewhat heavier than recent models of cell phones, this assumption may have caused an underestimate in the aggregate weight of mobile devices in the model.

- We used lifespan data based on the brand sort data from Florida DEP for the period 2004 to 2006. To the extent that used electronic products generation and management practices in Florida five years ago differ from national practices today, these data may not be representative of current national electronic product lifespans. At the same time, the Florida DEP data set has been analyzed against other "waste" sorts from different states with no statistically-significant difference found (EPA, 2008; p. 11). After consulting other sources, we determined that the Florida DEP brand sort data represents the best-available data on electronic products' lifespans.
- We have limited data on typical use, storage, and management practices in commercial institutions. As a result, our assumptions of use and storage of commercial products have a high degree of uncertainty. Actual use, storage, and end-of-life management practices will depend upon the practices of individual commercial institutions and will likely vary based on available recycling infrastructure, municipal- and state-level recycling policies, and the institution's own internal policies.
- Our estimate of the share of electronic products collected for recycling from commercial sources is based on the results from the survey of recyclers conducted for this report. The accuracy of this estimate will depend upon the extent that the aggregated survey results are representative of national electronics recycling operations.
- We have limited data on use and storage times for mobile devices. As a result, our assumptions of use and storage of mobile devices have a high degree of uncertainty. Actual use, storage, and end-of-life management practices will depend greatly upon the practices of individual consumers, and commercial businesses, as well as the technical age of mobile devices.
- There were also limited data on the share of electronic products that are collected for recycling versus disposal. We investigated several sources to help improve the accuracy of the assumptions in the model. For example, several states mandate the collection of information on electronics recycling, including the quantity of electronic products collected; in addition, mobile device manufacturers and carriers that sponsor take-back programs and often publicly report the results. The survey of electronics recyclers conducted for this study also provided an estimate of the amounts collected for recycling.

  However, due to overlaps, inconsistencies, and gaps between the sources, it was not possible to extrapolate the data to a national level. The product types covered by electronics recycling laws and the methods for reporting the quantity of electronic products collected vary from state to state. Additionally, we didn't account for collection activities in states with mandated programs that are not captured in the state's reported collection figures. Also, our results are particularly sensitive to our assumption that one pound of electronic products is collected for recycling per capita from residential sources in states that do not report the quantity of electronic products collected for recycling, and the assumption that roughly 67 percent of electronic products collected for recycling come from commercial sources.
- To estimate the share of mobile devices at end-of-life that are collected for recycling, we extrapolated the results gathered through a survey of three large mobile device recyclers. We believe there is considerable uncertainty in the estimated quantity of mobile devices collected for recycling in the United States.
- The popularity of particular types of electronic products continues to evolve rapidly; for example, touch-screen devices are increasing in popularity and are likely to affect the use, storage, and disposal of the devices that they replace, in ways that are not yet reflected in the model.
- We did not estimate international shipments of electronic products collected for recycling and then exported for reuse or recycling.

In this report, we provide a broad overview and improve the state of knowledge of how consumer electronic products are used and managed at their end-of-life in the United States. We have identified where considerable uncertainty exists in our model and assumptions. The updated data and model refinements implemented in this version of the report have helped to improve on several of the limitations encountered in the 2008 report.

Although this report provides a picture of the current situation in the United States, using the best data available, its broad scope does not account for variations at the regional, state, and local levels that are likely to influence the larger picture. State-level policies on the management of end-of-life electronic products differ dramatically across the United States, and regional differences in population density (especially between urban and rural areas), patterns of electronic products use, and the availability of recycling services affect the available opportunities for electronics collection.

Finally, the findings of this report are limited by the availability of hard data on the use and end-of-life management of electronic products. There is a need for improved and consistent reporting of electronic products collection and recycling. Comprehensive, nationally-representative data on the lifespans of electronic products, the patterns of use across residential and commercial institutions, and the quantity of electronic products collected for recycling do not yet exist. Further research, data gathering, and collaboration between stakeholders will be essential in developing a clearer picture of the management of used electronics at their end-of-life in the United States in the future.

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Appendix A: Definitions

Table A1: Key terms used in this report

In use	Electronic products that are still in use, either by their first owner or by a subsequent owner to whom the first owner has given or sold the product; but excluding electronic products that are in storage.
In storage	Electronic products that have been placed in storage; i.e., they are not in use, but have not yet been sent for end-of-life management.
End-of-life management	Electronic products are ready for end-of-life management when they are removed from use or storage and sent for disposal or recycling.
Collected for recycling	The post-consumer collection or otherwise handling of electronic products for subsequent reuse, refurbishment, and/or material recovery.
Material recovery	Processing disassembled pieces or shredded material into a commodity or new product
Reuse or refurbishment	Involves minor improvements, cleaning, and replacement of minor parts in preparation for electronic product resale.
Disposal	Landfilling electronic products or collecting combustible materials for waste-to-energy incineration.

Table A2: Product categories included in this report

Category	Product Type	Description	Scope of Product Type
Computers	Desktop CPUs	Non-portable personal computers (PCs), excluding external monitor	Includes "white boxes", or non-brand-name PCs assembled by vendors that purchase components; does not include mainframe computers, servers, thin clients[9]
	Portables	Portable, notebook, and laptop computers	Includes tablets, netbooks, ultra-compact laptops; does not include eBook readers, smartphones
Hard-copy devices	Hard-copy devices	Electronic devices used to produce or transfer printed documents	Includes printers, fax machines, scanners and digital copiers, multi-function devices; does not include stand-alone copier machines, modems, PC upgrade components, sound cards, external storage, and external hard drives
Keyboards and mice	Keyboards	External keyboards for use with PCs	Includes all keyboard categories
	Mice	External mice for use with PCs	Includes all mice categories

[9] A thin client is a network computer that does not contain a hard drive disk. Thin clients connect over a network to a server where most of the data processing occurs (HP 2009).

Computer displays	CRT monitors	Cathode ray tube (CRT) monitors for use with PCs	Includes all PC CRT monitor types
	Flat-panel monitors	Flat-panel monitors for use with PCs	Includes all PC flat-panel types
Televisions	Cathode Ray Tube (CRT) TVs	CRT or direct-view televisions	Includes digital direct-view CRT TVs, portable, table, and console, and CRT TV VCR/ DVD combination products
	Flat-panel TVs	Thin, flat, non-CRT TVs, other than projection TVs	Includes liquid-crystal displays (LCDs), plasma TVs, organic light-emitting diode TVs (OLED), and flat-panel TV combination products; does not include handheld TVs
	Projection TVs	Self-contained TVs that project the image onto the screen through a series of lenses and mirrors	Includes rear projection TVs; does not include front projection TVs
	Monochrome TVs	Black-and-white televisions	Includes black and white TVs
Mobile devices	Mobile devices	Portable, handheld wireless telephones	Includes standard wireless telephones (i.e., cell phones), personal digital assistants (PDAs), smartphones, pagers; does not include handheld TVs, portable MP3 and music players (iPods), digital cameras and camcorders

Appendix B: Summary of Updates to the Previous Study

This section describes the methodological changes and new data sources that have been used in this report to update EPA (2008) *Electronics Waste Management in the United States: Approach 1*. The main purpose of this report was to extend the data found in the 2008 report through 2009, and to project it into 2010.

The product scope remained the same, and—for the most part—the methodology and data sources used in this report are the same as those in the 2008 report. However, some changes and improvements were made and those are outlined below:

Sales Data

- Historical sales data sources remained the same for this report compared to the 2008 report. See Appendix C for details on sales data sources. For recent model years, we updated the number of electronic products sold based on shipments of domestic and imported electronics for sale in the United States from the following data sources:
    - Desktop CPUs, portables for model years 2008 to 2010 (IDC 2006a, Vokes 2009);
    - Hard-copy devices for model years 2008 to 2010 (IDC 2006b, Vokes 2009);
    - PC CRT monitors for model years 2008 to 2010 (IDC 2007; Vokes 2009);
    - PC flat-panel monitors for model years 2007 to 2010 (IDC 2007, Vokes 2009);
    - CRT TVs, flat-panel TVs for model years 2008 and 2009 (CEA 2009);
    - Projection TVs for model years 2007 to 2009 (CEA 2009);
    - Monochrome TVs for model years 2007 to 2010 (CEA 2009);
    - Estimated sales of mobile devices for model years 2008 to 2010.
- The 2008 report assumed a fixed, 62-percent share of electronic products are sold to the residential sector. For this report, we updated our estimates of the shares of electronic products sales that are residential (i.e., consumer electronic products) versus commercial based on multiple sources from industry associations and consultants (see Table 3 for details).

Weight Data

- We updated product weight data for all categories of electronic products through the 2009 model year, as found in *Consumer Reports* magazine, manufacturer specifications, and consumer electronic product reviews.
- Historical weight data sources remained the same for all products except for flat-panel TVs. In updating our weight data, we found that the average weight of flat-panel TVs in 2009 was nearly three times that reported in the 2008 report, with a 2008 average weight of 75.6 lbs. and a 2009 average of 80.6 lbs. The 2008 report assumed the average weight to be 29 lbs.

  Thus, to assess the historical trend in unit weights, we researched popular flat-panel models in 2005, and found that the average weight that year was 61.2 lbs. A linear regression for years between 1998 and 2005 was developed based on the new data for 2005 through 2009. We updated the model with this new trend line; the data used in the 2008 report were kept in place through the 1998 model year, after which the trend of increasing TV weight begins.

Storage

- The 2008 report did not include estimates of the number of commercial electronic products in storage. We surveyed existing literature for information on commercial storage, and updated this report to include an assumption that a certain portion of these electronic products are stored. We assumed that commercial desktop CPUs, portables, hard-copy devices, and computer monitors are kept in use for five years, after which 20 percent are stored for up to two additional years.

  This assumption is based on evidence that storage occurs in commercial institutions. Twenty percent of the participants in a 2005 survey of U.S. commercial institutions indicated they kept PC assets that were ready for disposal (Daoud 2007). The survey results reflect the number of companies that said they store electronic products—they did not indicate the number or percentage of electronic products stored.

- The 2008 report did not include estimates of the number of mobile devices in storage. In this report, we assumed that 20 percent of mobile devices are at their end-of-life at the end of two years, with an additional 70 percent sent to their end-of-life management at the end of five years, based on Moss (2010). We also assume that the remaining 10 percent of mobile devices are stored up to a total of 10 years, based on estimates from Niera (2006) and Singhal (2005) that cell phones can be kept in storage for up to 10 years.

Products Ready for End-of-life Management

- Table B1 shows the percent difference in the estimated quantity of electronic products ready for end-of-life management, for all products sold between 1980 and 2007, between the 2008 report, and this updated report.

  Our updated assumptions of the share of commercial electronic products have caused slight changes in the quantity of computer products ready for end-of-life management. Due to our updated storage assumptions, the number of computer products in use and storage has increased, and the number of mobile devices ready for end-of-life management has decreased.

Table B1: Percent difference in estimated used electronic management practice for all products sold between 1980 and 2007, for the results from this report, relative to the 2008 report.

Management Practice	Computer Products		TVs		Mobile Devices		Total	
	units	short tons	Units	short tons	units	short tons	units	short tons
Ready for end-of-life management	1.1%	3.1%	0.0%	0.0%	-31.1%	-22.6%	-6.8%	1.6%
In use and storage	48.0%	-*	1.8%	-*	-*	-*	-*	-*

* The percent difference couldn't be calculated due to lack of data in the 2008 report.

End-of-Life

- We updated our estimates of the annual quantity of electronic products at their end-of-life that is collected for recycling rather than disposed of.

  The 2008 report relied upon data from EPA's Facts and Figures report (EPA 2009) to estimate the total amount of electronics collected for recycling. From this, the 2008 report subtracted the quantity of mobile devices collected for recycling based on expert opinion. Finally, it assumed that the quantity of each product that was collected for recycling was proportional to the share that the electronic product comprised of the total number of products ready for end-of-life management each year.

  In this report, we used data from nine state-mandated electronics recycling programs, covering up to 29 percent of the U.S. population, to estimate the quantity of electronics products collected for recycling. For the remaining states that do not report on electronics

recycling, we assumed that one pound of electronics products per capita are collected from residences for recycling. We used data on the share of collection from commercial institutions to estimate the total quantity of electronic products collected for recycling for states that do not report collection from commercial sources. We investigated the sensitivity of the results to our assumptions of per-capita residential collection and the share of collection from commercial sources.

Appendix D provides a detailed description of the updated methodology. In Table B2, we have compared the rates at which electronic products are collected for recycling used in the 2008 report to our updated methodology.

Table B2: Comparison of this report's estimated rates at which individual electronic products are collected for recycling and the previous estimates used in the 2008 report

Category	Rate at which each product type is collected for recycling, as a percent of the total quantity of each product ready for end-of-life management in 2007	
	This Report	2008 Report
Computers (desktop CPUs and portables)	36%	19%*
Computer displays (CRT and flat-panel monitors)	24%	
Hard-copy devices	38%	
Mice and Keyboards	7%	
TVs (CRT, flat-panel, and projection TVs)	17%	18%
Mobile devices	7%	10%

* EPA (2008) did not distinguish between the rate at which computers, computer displays, hard-copy devices, and mice and keyboards are collected. Instead, the report assumed an average collection rate of 19 percent across these categories.

Appendix C: Sales Data Sources

Table C1: Sales data sources and assumptions, by product category and type. **Projections in sales based on sales for previous years and available data sources.*

Category	Product Type	Model Year	Source or Assumption
Computers	Desktop CPUs	1980-2007	IDC, as cited in the 2008 report
		2008-2009	IDC (2006a); Vokes (2009)
		2010*	Projected based on 5-year sales growth between 2004 and 2009.
	Portables	1992-2007	IDC, as cited in the 2008 report
		2008-2010*	Projection from Vokes (2009), based on IDC (2006a) data
Hard-copy devices	Hard-copy devices	1980-1995	Assumes 1.9 computers sold for every one hard-copy device, based on IDC data in 1980, as cited in the 2008 report
		1996-2007	The 2008 report
		2008-2010*	Projection from Vokes (2009), based on IDC (2006b) data
Keyboards and mice	Mice	1980-2010	Assumes sales are equal to desktop PCs; the 2008 report
	Keyboards	1980-1989	Assumes sales are equal to desktop PCs
		1990-2006	The 2008 report
		2007-2010	Assumes growth rate in sales are equal to growth rate in sales of desktop PCs
Computer Displays	PC CRT monitors	1980-1988	Assumes sales are equal to desktop PCs
		1989-2003	The 2008 report
		2003-2007	IDC data, as cited in the 2008 report
		2008-2010*	Projection from Vokes (2009), based on IDC (2007) data
	PC flat panels	1989-2006	The 2008 report
		2006-2010*	Projection from Vokes (2009), based on IDC (2007) data
Televisions	CRT TVs	1980-2007	CEA (2005), as cited in the 2008 report; assumed 50/50 split between <19" and >=" CRT TVs between 1980 and 1990.
		2007-2009	CEA (2009); split between <19" and >=19" CRT TVs based on iSuppli (2006) and Vokes (2009)
		2010*	Projected based on 2008/2009 trend
	Flat-panel TVs	1989-2007	CEA, as cited in the 2008 report
		2008-2009	CEA (2009)
		2010*	Projected based on Display Search (2007) and Vokes (2009) projections for 2010
	Projection TVs	1984-2006	CEA data, as cited in the 2008 report
		2007-2009	CEA (2009)
		2010*	Projected based on Display Search (2007) and Vokes (2009) projections for 2010
	Monochrome TVs	1980-2007	CEA data, as cited in the 2008 report
		2007-2010	CEA (2009)
Mobile devices	Mobile devices	1984-1995	Projected backwards from Fishbein (2002) data based on CEA (2005), as cited in the 2008 report
		1996-2007	IDC data, as cited in the 2008 report
		2008-2010*	Projected based on 2004 to 2009 5-year average growth rate calculated from CEA (2009)

Appendix D: Detailed Methodology for Estimating the Quantity of Electronic Products Collected for Recycling in the United States

For this report, we updated our estimates of the quantity of end-of-life electronic products collected for recycling to incorporate state reports on electronic products recycling and the results from the survey of recyclers. Since the methodology involves a number of data sources and assumptions, we have provided a detailed description of our approach in this appendix. The methodology used to estimate the quantity of electronic products collected for recycling is as follows:

1. We compiled reports on the quantity of electronic products collected through state-mandated collection programs, where data were available. Information was available from states representing roughly 29 percent of the U.S. population in 2009 (see Table D1). These state data only included residential recycling, except for California, which included both residential and commercial recycling. In addition, the types of devices allowed varied from state to state. We did not account for collection activities occurring outside of the state-mandated collection programs within these states.
2. For states where 2009 collection numbers were not yet available, we extrapolated per-capita rates for 2009 based on the per-capita rates of collection in 2008 (see Table D2).
3. For the remaining states where information was unavailable, we applied an assumption of one pound of electronic products collected per capita from residential sources. For states that do not have electronics recycling laws or reporting in place, this assumption corresponds to a collection rate that is roughly equivalent to the per-capita collections in states reporting low levels of collection (i.e. Maryland, Virginia, and Texas), and between one third to one sixth the per capita rate of states reporting higher levels of collection (i.e., Maine, Minnesota, Washington, Oregon, and Delaware).
4. To estimate commercial recycling, we assumed that 67 percent of the products collected for recycling come from commercial sources, based on the results from the survey of seven recyclers. For states where the quantity of commercial electronics collected was not reported, we back-calculated the total collection for recycling from the quantity of residential products collected based on this 67-percent assumption.

Table D1: Tonnages of electronic products collected for recycling, as reported in state electronics recycling reports. ** Estimated assuming a constant per-capita rate between 2008 and 2009 for states that had not yet reported. "–" indicates that no report was available.*

State	2006 short tons	2007 short tons	2008 short tons	2009 short tons
California	63,990	92,279	108,032	81,002
Maine	1,924	2,344	2,637	3,956
Maryland	3,136	4,350	--	--
Minnesota	--	16,800	13,750	13,844*
Washington	--	--	--	19,274
Oregon	--	--	--	9,486
Delaware	1,407	1,600	1,796	2,000
Texas	--	--	--	7,624
Virginia	--	--	--	3,823
Total	70,457	117,373	126,215	141,009

Table D2: Per capita rates of electronics collection for recycling. **Assumed per-capita rates for states that had not yet reported in 2009. "--" indicates that no report was available.*

State	2006	2007	2008	2009
	lbs per capita	lbs per capita	lbs per capita	lbs per capita
California	3.56	5.09	5.91	4.38
Maine	2.93	3.56	4.00	6.00
Maryland	1.12	1.54	--	--
Minnesota	--	6.47	5.26	*5.26**
Washington	--	--	--	5.78
Oregon	--	--	--	4.96
Delaware	3.30	3.70	4.10	4.52
Texas	--	--	--	0.62
Virginia	--	--	--	0.97
Average	2.73	4.07	4.82	4.06

5. We summed the estimated quantities of residential and commercial electronic products collected for recycling to calculate the total tonnage of electronics collected for recycling.
6. Our estimate of the quantity of electronic products collected for recycling is highly sensitive to two assumptions: first, that one pound per capita of electronic products are collected for recycling from states that do not report collection quantities, and second, that 67 percent of collected electronic products come from commercial sources. We conducted a sensitivity analysis to investigate the effect of these assumptions on our estimated rate of collection for recycling. The sensitivity analysis included two scenarios, explained below and summarized in Table D5:
    a. A "Residential Collection Rate" analysis, where we assumed an upper-bound limit of two pounds per capita of electronic products and a lower-bound limit of 0.5 pounds per capita of electronic products collection for recycling in states that do not report collection rates (see Table D3 and Figure D1).
    b. A "Commercial Share of Collection" scenario, where we assumed that commercial collection accounts for an upper-bound of three-quarters of the total quantity of electronic products and a lower-bound of half the total quantity of electronic products collected for recycling in states that do not report commercial collection (see Table D4 and Figure D2).

We also investigated a worst-case/best-case estimate by combining the high residential collection assumption (two lbs per capita) with the high share of commercial collection (three-quarters of total collection), and the low residential collection assumption (0.5 lbs per capita) with the low share of commercial collection. This provided a highest possible recycling rate estimate of 48 percent, and a lowest possible recycling rate estimate of 16 percent.

Table D3: Residential Collection Rate Scenario -- Estimated tonnages of electronic products collected for recycling, and the rate of collection for recycling as a percent of total electronics ready for end-of-life management in 2009.

	2006	2007	2008	2009	Rate of electronics collection for recycling in 2009
	short tons	short tons	short tons	short tons	%
Default Scenario (i.e., residential per-capita collection rate is one lbs)					
Residential	197,874	243,547	256,400	250,719	--
Commercial	271,825	307,119	301,231	344,576	--
Total	469,699	550,665	557,630	595,295	25%
Residential Collection Rate Scenario – Upper Bound (i.e., residential per-capita collection rate of two lbs)					
Residential	325,290	369,720	386,584	360,429	--
Commercial	530,520	563,288	565,544	567,321	--
Total	855,810	933,008	952,127	927,750	39%
Residential Collection Rate Scenario – Lower Bound (i.e. residential per-capita collection rate of 0.5 lbs)					
Residential	134,165	180,460	191,308	195,864	--
Commercial	142,478	179,034	169,074	233,204	--
Total	276,643	359,494	360,382	429,067	18%

Table D4: Commercial Share of Collection Scenario -- Estimated tonnages of electronic products collected for recycling, and the rate of collection for recycling as a percent of total electronics ready for end-of-life management in 2009.

	2006	2007	2008	2009	Rate of electronics collection for recycling in 2009
	short tons	short tons	short tons	short tons	%
Default Scenario (i.e., commercial share of collection is 67 percent of total)					
Residential	197,874	243,547	256,400	250,719	--
Commercial	271,825	307,119	301,231	344,576	--
Total	469,699	550,665	557,630	595,295	25%
Commercial Share of Collection Scenario – Upper Bound (i.e., commercial share collection is three quarters of total)					
Residential	197,874	243,547	256,400	250,719	--
Commercial	395,381	429,468	427,470	450,962	--
Total	593,254	673,015	683,869	701,681	30%
Commercial Share of Collection Scenario – Lower Bound (i.e., commercial share of collection is half of total)					
Residential	197,874	243,547	256,400	250,719	--
Commercial	140,547	177,122	167,102	231,541	--
Total	338,421	420,669	423,501	482,260	20%

Table D5: Summary of the assumptions for per-capita residential collection, and the share of electronic products collected for recycling from commercial institutions in the default case and sensitivity analyses.

	Pounds per-capita of residential electronics collected for recycling (lbs per capita)	Share of electronics collected for recycling from commercial institutions (%)
Default value	1.0	67%
High value	2.0	75%
Low value	0.5	50%

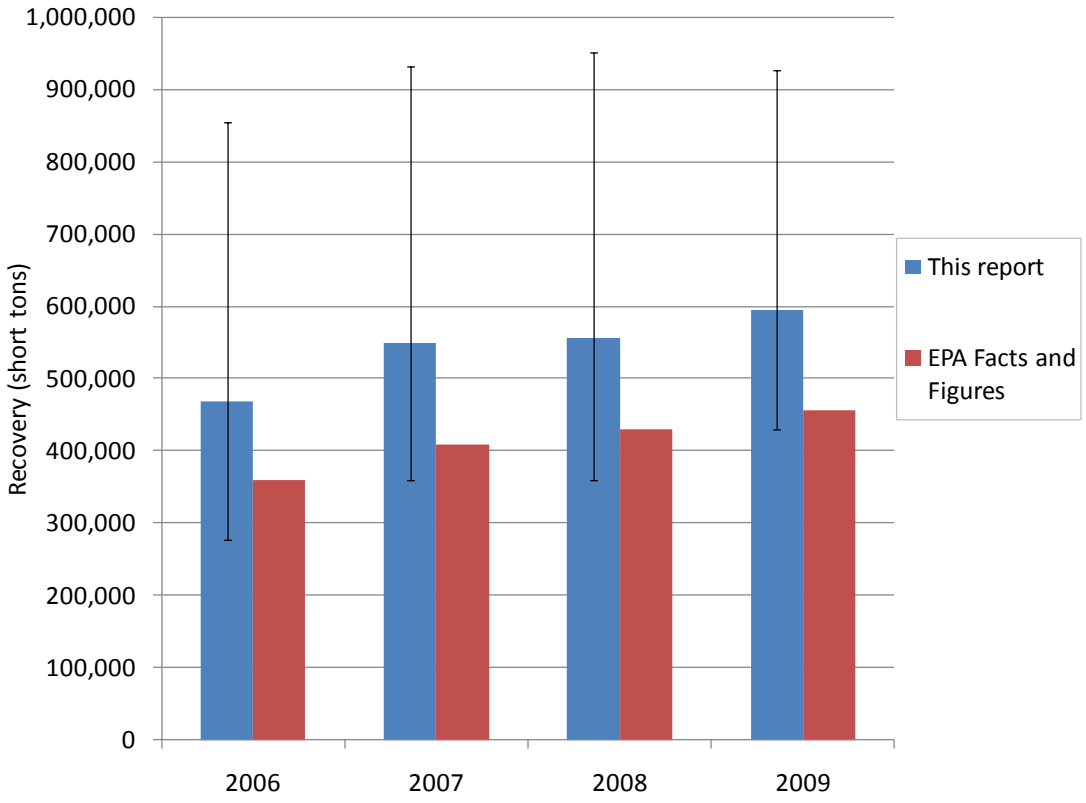

Figure D1: Comparison of the estimated tonnages of electronic products collected for recycling from this report with EPA (2008) Approach 1 – with error bars reflecting residential collection rate scenarios. *EPA (2008) data based on EPA (2009) Error bars represent the range of tonnage of electronics collected for recycling under the high and low bounds of the Residential Collection Rate scenario.*

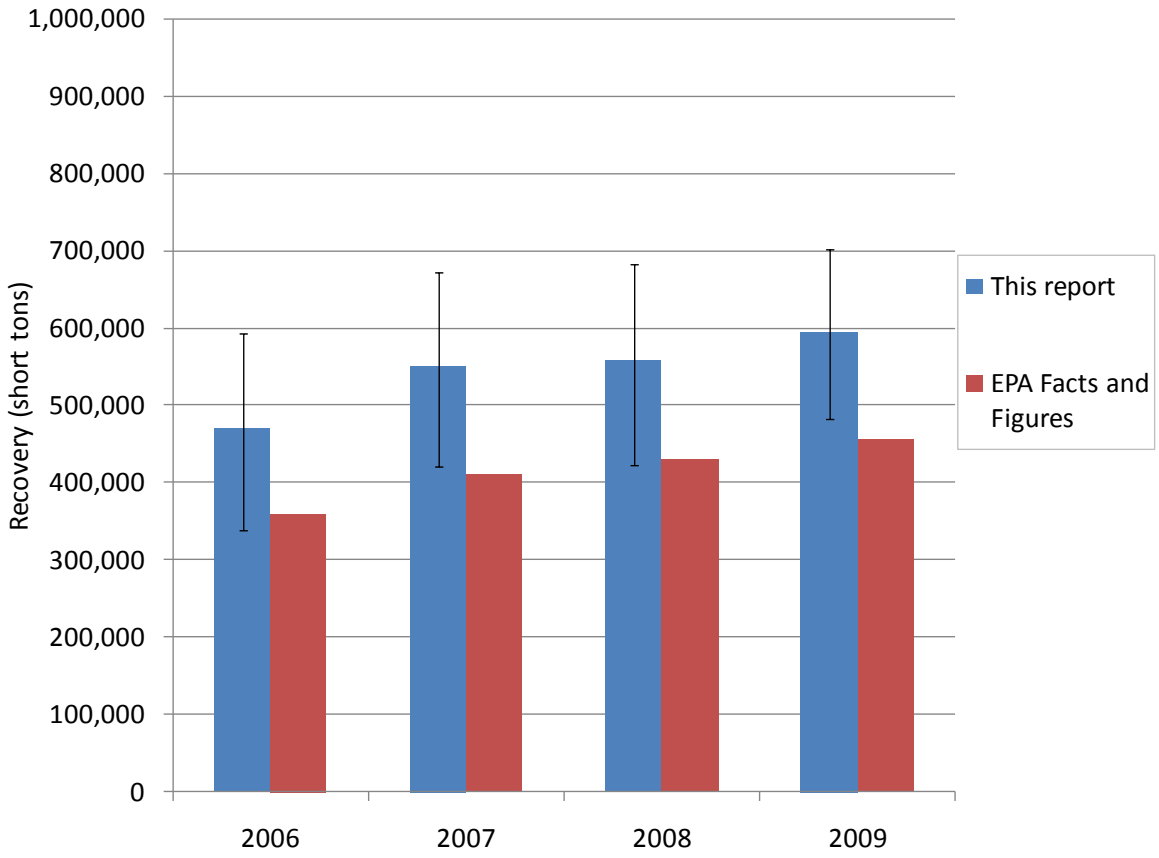

Figure D2: Comparison of the estimated tonnages of electronic products collected for recycling from this report with EPA (2008) Approach 1 – with error bars reflecting commercial collection rate scenarios. *EPA (2008) data based on EPA (2009) Error bars represent the range of tonnage of electronics collected for recycling under the high and low bounds of the Commercial Collection Rate scenarios.*

7. We projected the rate that electronic products would be collected for recycling in 2010 by calculating the average growth rate in our estimates of collection for recycling between 2006 and 2008—the years for which the highest number of states reported data. Based on this trend, the rate at which electronic products are collected for recycling will increase by nine percent, to roughly 649 thousand short tons in 2010.

   Although our results reflect recent trends in the increasing quantities of electronic products collected for recycling, this amount could increase further if major electronics recycling programs achieve 2010 collection targets that they have recently established. For example, the Illinois Environmental Protection Agency has set a statewide goal to collect 16,000 short tons in 2010 (roughly 2.5 pounds per capita) (Illinois EPA 2010); the Wisconsin Department of Natural Resources (2010) estimates that it will collect between 15 and 18 million pounds in the first half to 2010 by targeting 80% of covered electronics products sold to households and public schools (K to 12), and Indiana has set a target of collecting 60% of covered electronic products sold to households starting in April 2010 (Recycle Indiana (2010).

8. To estimate the quantity of mobile devices collected for recycling, we used two pieces of information from the survey of mobile device recyclers that was conducted for the report:

   a. The number of products collected for recycling between 2007 and 2009, and

   b. The self-estimated market share of the largest of the recyclers between 2007 and 2009.

Using this data, we back-calculated the total number of mobile devices collected for recycling in 2007 through 2009 (i.e., the total recycling market). This gave us an estimate of 8.3 million devices—or seven percent of the mobile devices at their end-of-life—collected for recycling in 2007, increasing to 11.8 million devices, or an eight-percent rate of collection for recycling, in 2009. This estimate has a high degree of uncertainty, due to a lack of knowledge about the true total number of mobile devices collected for recycling and the market shares of individual recyclers.

9. Next, we used a growth trend in the collection of mobile devices for recycling from 2006 to 2008 to extrapolate the rate of collection from 2006 to 2010. We used information on the quantity of mobile devices collected in take-back programs run by mobile device manufacturers and carriers. Based on this data, we projected an 11-percent rate of mobile device collection for recycling in 2010.

10. Finally, we estimated the individual rates of collection for recycling across the other product types covered in this report:

    a. First, we subtracted the quantity of mobile devices collected for recycling from the total quantity of electronics products collected.

    b. Next, we calculated the average distribution of electronic products collected for recycling—excluding mobile devices—from the results of the survey of electronics recyclers conducted for this report (see Table 7).

    We then applied this average distribution to the amount of electronic products collected for recycling (excluding mobile devices) in each year between 2006 and 2010 to estimate the quantity of each product type collected for recycling. The results are shown in Table 11 for each product type.